# LBA CCS TRANSPORT AND STORAGE PROJECT

POINT OF AYR TO SATELLITE PLATFORMS

OFFSHORE NEW PIPELINES PRELIMINARY CROSSING REPORT

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**HOLD RECORD**

| | |
|---|---|
| 1. | Geotechnical and Geophysical survey reports |
| 2. | Deleted |
| | |
| | |
| | |

**ASSUMPTIONS RECORD**

| | |
|---|---|
| 1. | At the Douglas CCS platform new pipelines will cross the existing 14" (PL 1031) Oil pipeline to OSI. Number of crossings to be verified further with the De-commissioning scope for the Project. |
| | |
| | |

**Contents**

**1.0 INTRODUCTION .... 5**

1.1 PROJECT OVERVIEW .... 5
1.2 PURPOSE AND SCOPE .... 5

**2.0 DEFINITIONS AND ABBREVIATIONS .... 9**

2.1 DEFINITIONS .... 9
2.2 ABBREVIATIONS .... 9

**3.0 REFERENCES .... 10**

3.1 PROJECT DOCUMENTS .... 10
3.2 COMPANY/CLIENT SPECIFICATIONS .... 10
3.3 INTERNATIONAL CODES AND STANDARDS .... 10
3.4 OTHERS .... 10
3.5 ORDER OF PRECEDENCE .... 11

**4.0 SUMMARY AND RECOMMENDATION .... 12**

4.1 CROSSING LIST SUMMARY .... 14
4.2 RECOMMENDATION .... 16

**5.0 CROSSING IDENTIFICATION .... 17**

5.1 CROSSINGS .... 17
*5.1.1 New 16in Future Pipeline from Douglas CCS Platform to Lennox Platform .... 18*
*5.1.2 New 12in Future Pipeline from Douglas Platform to Hamilton North Platform .... 19*
*5.1.3 New 16in Future Pipeline from Douglas CCS Platform to Hamilton Main Platform .... 19*
*5.1.4 14in PL1041 Spool - Douglas CCS Platform to Hamilton North .... 19*
*5.1.5 16in PL1035 Spool - Douglas CCS Platform to Lennox .... 20*
*5.1.6 20in PL1039 Spool – Douglas CCS to Hamilton Main .... 20*
*5.1.7 12in PL1036A Spool – Douglas CCS to Lennox .... 20*
*5.1.8 Spool for Douglas CCS Platform to New Future Pipeline to Hamilton Main .... 20*

**6.0 CROSSING CRITERIA .... 22**

6.1 PIPELINE CROSSING DESIGN REQUIREMENTS .... 22

**7.0 INPUT DATA .... 23**

7.1 PIPELINE AND SPOOL DATA .... 23
7.2 CONCRETE WEIGHT COATING PROPERTIES .... 24
7.3 WATER DEPTH .... 25
7.4 WAVES DATA .... 26
*7.4.1 Douglas Field .... 27*
*7.4.2 Hamilton Field .... 27*
*7.4.3 Hamilton North Field .... 28*
*7.4.4 Lennox Field .... 28*
7.5 CURRENTS DATA .... 29
*7.5.1 Douglas Field .... 29*
*7.5.2 Hamilton Field .... 30*
*7.5.3 Hamilton North Field .... 31*
*7.5.4 Lennox Field .... 32*

**8.0 TYPICAL CROSSING METHODOLOGY .... 33**

8.1 CROSSING WITH MATTRESS .... 33
8.2 CROSSING WITH ROCK BERM .... 34
8.3 CROSSING WITH CONCRETE SLEEPER .... 35

**9.0 ALLOWABLE FREE SPAN ASSESEMENT .... 39**

9.1 ALLOWABLE FREE SPAN – EXISTING PIPELINES ... 40
9.2 ALLOWABLE FREE SPAN – NEW FUTURE PIPELINES ... 41

**10.0 PIPELINE LIFT-OFF FROM SLEEPERS ... 42**

**11.0 CONCRETE MATTRESS DESIGN REQUIREMENTS ... 43**

11.1 MATTRESS SPECIFICATION ... 43
11.2 DESIGN FEATURES ... 43
11.3 DESIGN REQUIREMENTS FOR STABILISATION ... 43
*11.3.1 Stability Against Leading Edge Lift ... 43*
*11.3.2 Stability Against Sliding ... 44*
11.4 MATTRESS ORIENTATION / PLACEMENT ... 45
11.5 DESIGN REQUIREMENTS FOR PROTECTION ... 45

**12.0 ROCK DUMPING DESIGN REQUIREMENTS ... 46**

12.1 ROCK BERM REQUIREMENTS ... 46

**13.0 CROSSING PROTECTION REQUIREMENT ... 47**

13.1 DROPPED OBJECT ... 47
13.2 FISHING GEAR INTERACTION ... 47

**14.0 ATTACHMENTS ... 49**

14.1 NEW 16IN FUTURE PIPELINE – DOUGLAS CCS TO LENNOX ... 49
14.2 NEW 12IN FUTURE PIPELINE – DOUGLAS CCS TO HAMILTON NORTH ... 49

# 1.0 INTRODUCTION

## 1.1 Project Overview

Refer to Offshore Project Basis of Design, document 1025H0BGRB09002 [Ref.1].

## 1.2 Purpose and Scope

The scope of this document is to identify the number of pipeline and cable crossings foreseen for the new offshore pipelines and spools in the LBA CCS transport and Storage Project. The new pipelines and spools within the scope of this document are shown in Figure 1-3 and Figure 1-3 identified in blue and includes:

- New 16in Future Pipeline and Spool from Douglas CCS Platform to Hamilton Main Platform
- New 12in Future Pipeline from Douglas CCS Platform to Hamilton North Platform
- New 16in Future Pipeline from Douglas CCS Platform to Lennox Platform
- Existing 14in PL1041 Pipeline Douglas to Hamilton North – Spool at Douglas CCS Platform
- Existing 16in PL1035 Pipeline Douglas to Lennox – Spool at Douglas CCS Platform
- Existing 20in PL1039 Pipeline Douglas to Hamilton Main – Spool at Douglas CCS Platform
- Existing 12in PL1036A Pipeline Douglas to Lennox – Spool at Douglas CCS Platform

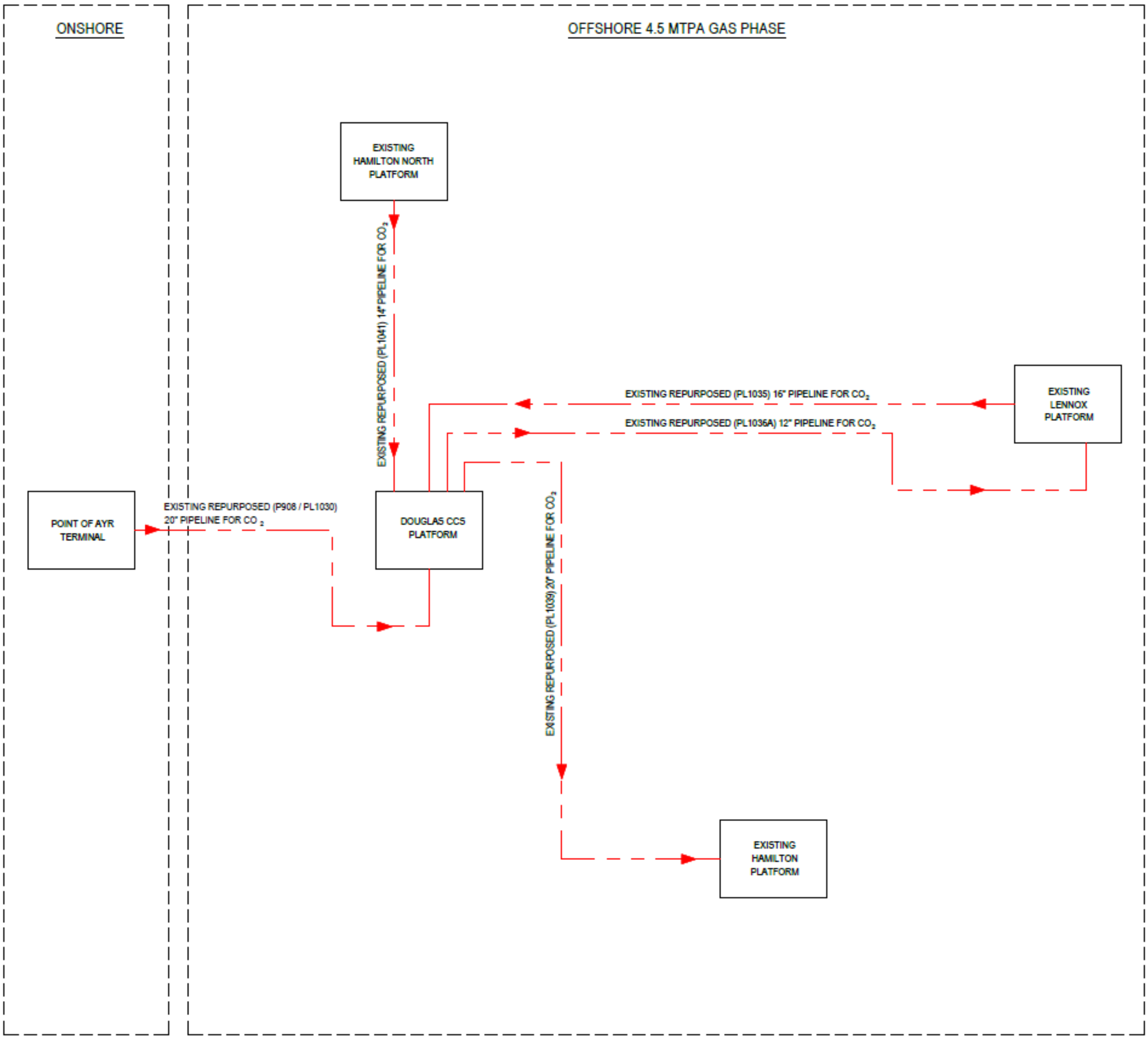


**Figure 1-1: Offshore Existing Pipelines Simplified Schematic (Base Case up to 4.5 MTPA)**

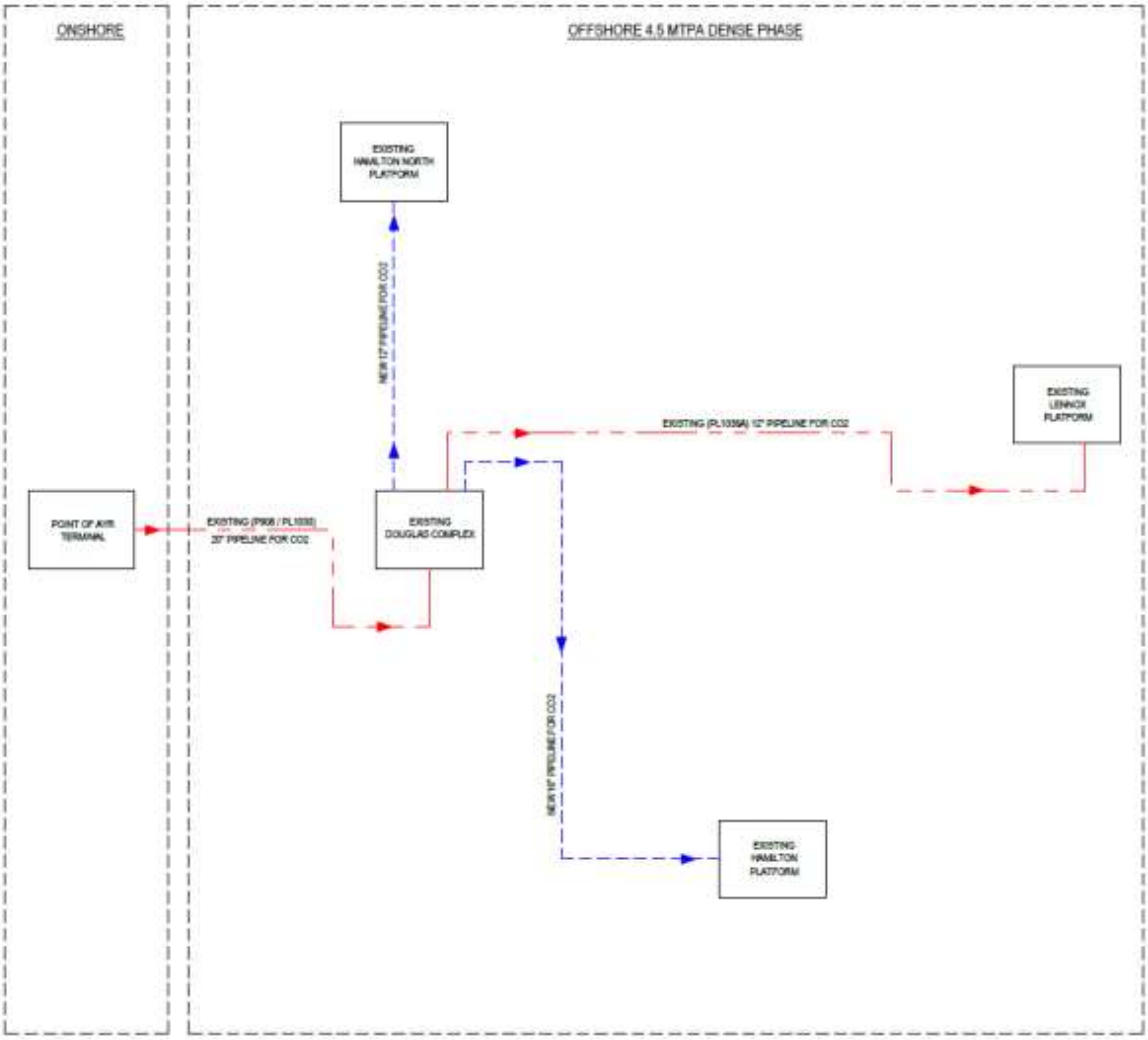


**Figure 1-2: New Offshore Future and Existing Pipelines Simplified Schematic (Design Case 4.5 MTPA)**

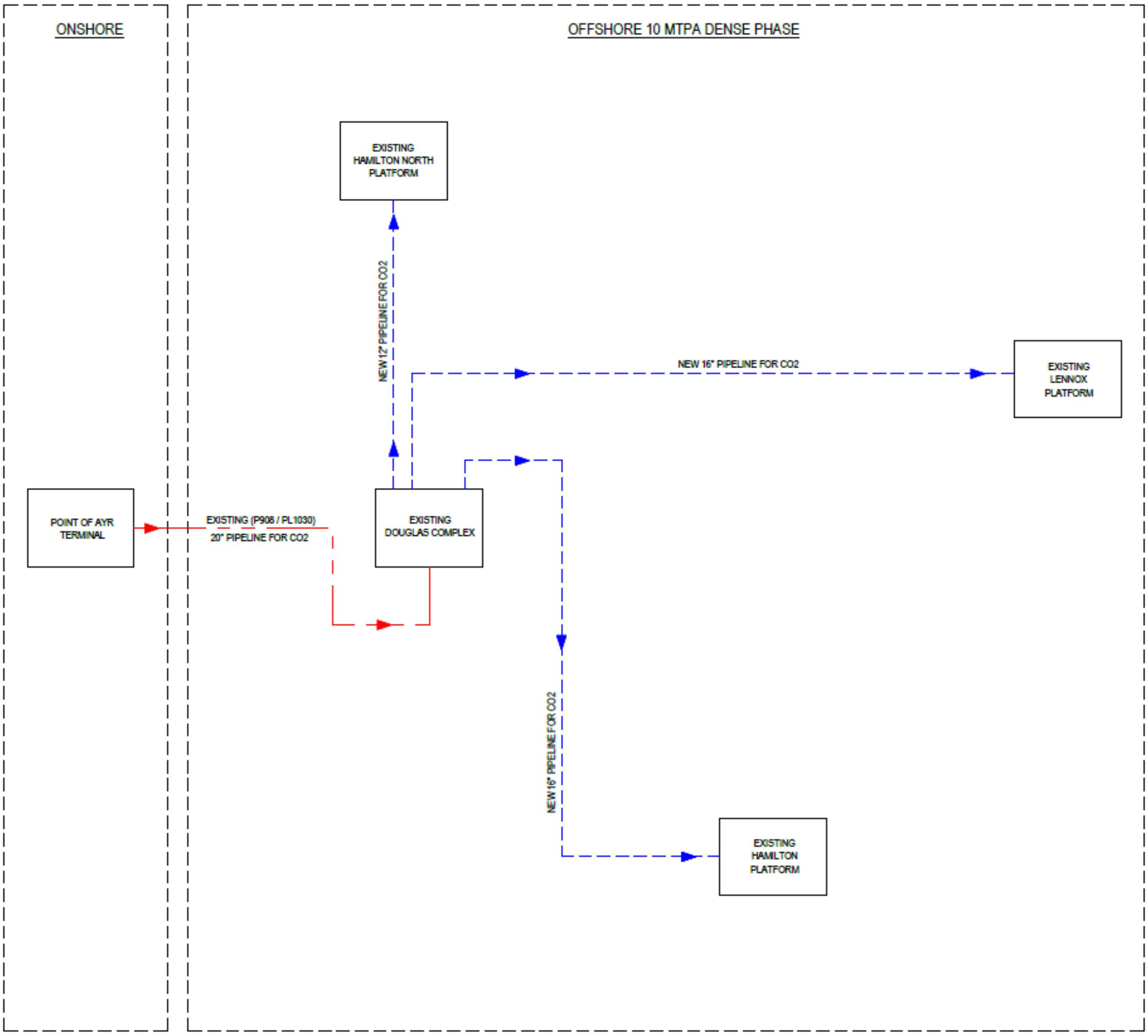


**Figure 1-3: New Offshore Future and Existing Pipelines Simplified Schematic (Design Case 10 MTPA)**

## 2.0 DEFINITIONS AND ABBREVIATIONS

### 2.1 Definitions

The following definitions, terminology and abbreviations are applicable for the Project and used throughout this document:

| | |
|---|---|
| COMPANY/CLIENT | The party that initiates the project and ultimately pays for its design and construction i.e. Eni UK. The COMPANY/CLIENT will generally specify technical requirements. The term “COMPANY/CLIENT” also includes agents or consultants authorized to act for and on behalf of COMPANY/CLIENT. Eni UK is the Client for LBA CCS Transport and Storage |
| CONTRACTOR | A person or organisation that undertakes responsibility for the execution of a CONTRACT. EniProgetti is responsible for execution of the Scope of work agreed with the COMPANY/CLIENT |
| CONTRACT | An acceptance of legal relations between two or more parties for the transfer of goods or services for value. |
| Project or Plant: | LBA CCS Transport and Storage |
| WORK | shall mean all work that CONTRACTOR is required to carry out in accordance with the provisions of CONTRACT including all related services and resources to be provided in accordance with the CONTRACT |
| SHALL | A mandatory provision |
| SHOULD | An advisory provision |

### 2.2 Abbreviations

| | |
|---|---|
| CCS | Carbon Capture and Storage |
| DNV | Det Norske Veritas |
| FEED | Front-End Engineering Design |
| LBA | Liverpool Bay Asset |
| MTPA | Million Ton Per Annum |
| N/A | Not Applicable |

## 3.0 REFERENCES

For all the applicable project documents, ENI company standards and international standards intended to be used for FEED engineering activities, refer to Project List of Applicable Codes and Standards [Ref.2].

### 3.1 Project Documents

| | |
|---|---|
| **[Ref.1]** | 1025H0BGRB09002, Basis of Design Offshore 4.5 MTPA (Gas Phase) – FEED &10 MTPA (Dense Phase) – Feasibility |
| **[Ref.2]** | 102100BESB09003, Project List of Applicable Codes and Standards |
| **[Ref.3]** | 1023DSBSRA84001, Offshore New Pipelines Design Requirements |
| **[Ref.4]** | 1023DSBSDN84003, Offshore New Pipelines Field Layout |
| **[Ref.5]** | 1023DSBSRV84008, Offshore Pipeline Preliminary Routing Report |
| **[Ref.6]** | 1023DSBSRA84018, Preliminary Pipelines and Tie-in Spools Protection Requirement Study |
| **[Ref.7]** | 1025H0BSRV84107, Offshore Power Cable Protection Requirement |
| **[Ref.8]** | 1025H0BSDG84104, Offshore Power Cable - Field Layout |
| **[Ref.9]** | 1023DDBSDN84004 - Pipeline Approach Drawing Douglas Platform |
| **[Ref.10]** | 1025HHBSDN84005 - Pipeline Approach Drawing Hamilton Main Platform |
| **[Ref.11]** | 1025HNBSDN84006 - Pipeline Approach Drawing Hamilton North Platform |
| **[Ref.12]** | 1024LDBSDN84007 - Pipeline Approach Drawing Lennox Platform |
| **[Ref.13]** | 1022DEBLDG80017 - Subsea Removals Around - Douglas Complex |
| **[Ref.14]** | 1022DEBLDG80018 - Subsea Removals Around – Hamilton Main |
| **[Ref.15]** | 1022DEBLDG80019 - Subsea Removals Around – Hamilton North |
| **[Ref.16]** | 1022DEBLDG80020 - Subsea Removals Around – Hamilton East |
| **[Ref.17]** | 1022DEBLDG80021 - Subsea Removals Around – Lennox |
| **[Ref.18]** | 1022DEBLDG80022 - Subsea Removals Around – OSI |
| **[Ref.19]** | 1023DSBSRV83530 – Requalification-Existing Pipelines - Free Span Assessment Report |
| **[Ref.20]** | 1025DSBSCZ84173 – Offshore Cables Preliminary Crossing Design Report |
| **[Ref.21]** | 1023DSBSRV84013 – Offshore New Pipelines On-Bottom Stability Report |
| **[Ref.22]** | 105600BSRV84155 - Repurposed Pipelines Tie-In Spool Analysis - Douglas CCS |

### 3.2 COMPANY/CLIENT Specifications

COMPANY/CLIENT Specifications to comply with [Ref.2].

| | |
|---|---|
| **[Ref.23]** | 23025.ENG.PLI.PRG, Design of Offshore Pipelines |
| **[Ref.24]** | 23015.ENI.PLI.STD, Pre-Construction Marine Survey |
| **[Ref.25]** | 23009.ENG.PLI.STD, Purchase and Installation of Flexible Mattresses to Protect, Stabilise and Support Offshore Pipelines |
| **[Ref.26]** | 23008.ENG.PLI.STD, Purchase and Installation of Rock dump over Offshore Pipelines for Intervention Purposes |

### 3.3 International Codes and Standards

International Codes and Standards to comply with [Ref.2].

| | |
|---|---|
| **[Ref.27]** | DNV-ST-F101 – Submarine Pipeline System |
| **[Ref.28]** | DNV-RP-F105 – Free Spanning Pipelines |

### 3.4 Others

External Survey Reports

(Hold 1)

| | |
|---|---|
| **[Ref.29]** | D-200-QR-013 – Liverpool Bay Development -Pipeline Design Report |
| **[Ref.30]** | CWY-KWL-PPL-REP-10010 – Conwy Field Development - Pipeline, Spool & Umbilical Protection Report |

**[Ref.31]** CWY-KWL-PPL-REP-10005 – Conwy Field Development – Seabed Mobility, Trenching and Infilling Assessment

**[Ref.32]** CWY-KWL-PPL-LEP-10001 – Conwy Field Development - Overall Field Layout

**[Ref.33]** CWY-KWL-PPL-DWG-10003-01 to 05 – Water Injection & Umbilical Alignment Sheet

**[Ref.34]** CWY-KWL-PPL-DWG-10002-01 to 05 – Production & Condensate Alignment Sheet

### 3.5 Order of Precedence

Should conflict arise between the statements of different rules, codes or standards, the following list of precedence SHALL be respected:

1. Law and National Standards
2. Design Basis, Project Specifications and Drawings
3. COMPANY/CLIENT Specifications
4. International Codes and Standards

If conflicts arise the most stringent requirement SHALL apply in its entirety of the specific topic. In all cases of conflict, the COMPANY/CLIENT SHALL be informed.

## 4.0 SUMMARY AND RECOMMENDATION

All the existing pipelines or cables to be crossed are all buried in accordance with [Ref.7], [Ref.29] to [Ref.34]. For LBA CCS project, all the new future pipelines and spools at the Douglas CCS platform approach, the crossing design is based on the use of concrete sleepers. Mattresses are also proposed to protect the whole spools length at the Douglas CCS approach up to the tie-in point location. Protection details are provided in preliminary pipelines and tie-in spools protection requirement study [Ref.6] and mattress stability assessment are provided in offshore cables preliminary crossing report [Ref.20].

Total number of identified crossings for the new future pipelines and spools, concrete sleepers and proposed height are presented in Table 4-1.

| Pipeline | Total - Number of Crossings | Total - Concrete Sleepers | Proposed Concrete Sleeper Height (m) |
|---|---|---|---|
| 16in New Future Pipeline - Douglas CCS to Lennox | 7 | 22 | 1 |
| 12in New Future Pipeline – Douglas CCS to Hamilton North | 4 | | |
| 16in New Future Pipeline - Douglas CCS to Hamilton Main | 0 | | |
| 14” Spool (PL1041) – Douglas CCS to Hamilton North | 1 | 6 | 1.1 |
| 16” Spool (PL1035) – Douglas CCS Lennox | 1 | | |
| 20” Spool (PL1039) – Douglas CCS to Hamilton Main | 1 | | |
| 12” Spool (PL1036A)– Douglas CCS to Lennox | 1 | | |
| 16” Spool – New Future Douglas CCS to Hamilton Main | 1 | | |
| **Total** | **16** | **28** | - |

**Table 4-1 Total number of Crossings, Concrete Sleepers and Height – LBA CCS New Future Pipelines and Spools**

Crossing design calculation has been performed using DNV PET program for the allowable free span screening based on DNV – RP-105 [Ref.28] for a range of water depths along the new future pipelines. Results are presented in Table 4-2. Allowable free spans for the existing pipelines are extracted from the requalification-existing pipelines – free span assessment report [Ref.19] and presented in section 9.1.

| Pipeline | Mode | Max Allowable Span Length (m) | | |
|---|---|---|---|---|
| | | Static | In-Line | Cross-Flow |
| 16in New Future Pipeline – Douglas CCS to Lennox | Installation | 59.2 | 10.84 | 23.6 |
| | Hydrotest | 49.69 | 10.37 | 22.73 |
| | Operational | 12.58 | 9.42 | 12.58 |
| 12in New Future Pipeline – Douglas CCS to Hamilton North | Installation | 49.42 | 8.62 | 17.36 |
| | Hydrotest | 39.86 | 8.28 | 16.71 |
| | Operational | 12.11 | 7.51 | 12.11 |
| 16in New Future Pipeline – Douglas CCS to Hamilton Main Note 1 | Installation | 59.2 | 10.84 | 23.6 |
| | Hydrotest | 49.69 | 10.37 | 22.73 |
| | Operational | 12.58 | 9.42 | 12.58 |
| Notes:<br>1 – Mechanical, environmental and sea state data are the same as used for 16in new future pipeline (Douglas CCS – Lennox) free span analysis. Therefore, no further analysis has been performed. | | | | |

**Table 4-2 Summary of Allowable Free Spans- LBA CCS New Future Pipelines**

Maximum pipeline liftoff from the sleepers have been summarized in Table 4-3.

| Spool ID | Location | Condition | Phase | Node | Liftoff |
|---|---|---|---|---|---|
| [-] | [-] | [-] | [-] | [-] | [mm] |
| PL1041 | Douglas CCS | Operation | Gas | Near Sleeper | 0.00 |
| | | | | Far Sleeper | 0.00 |
| | | Hydrotest | Gas | Near Sleeper | 0.00 |

| Spool ID | Location | Condition | Phase | Node | Liftoff |
|---|---|---|---|---|---|
| [-] | [-] | [-] | [-] | [-] | [mm] |
| | | | | Far Sleeper | 0.00 |
| PL1035 | Douglas CCS | Operation | Gas | Near Sleeper | 1.27 |
| | | | | Far Sleeper | 0.00 |
| | | Hydrotest | Gas | Near Sleeper | 0.00 |
| | | | | Far Sleeper | 0.00 |
| PL1039 | Douglas CCS | Operation | Gas | Near Sleeper | 4.21 |
| | | | | Far Sleeper | 0.94 |
| | | Hydrotest | Gas | Near Sleeper | 0.25 |
| | | | | Far Sleeper | 0.00 |
| PL1036A | Douglas CCS | Operation | Gas | Near Sleeper | 11.71 |
| | | | | Far Sleeper | 18.68 |
| | | Hydrotest | Gas | Near Sleeper | 13.14 |
| | | | | Far Sleeper | 13.01 |
| | | Operation | Dense | Near Sleeper | 30.83 |
| | | | | Far Sleeper | 23.17 |
| | | Hydrotest | Dense | Near Sleeper | 6.54 |
| | | | | Far Sleeper | 9.31 |

**Table 4-3 Summary Table – Pipeline Liftoff From Sleepers**

## 4.1 Crossing List Summary

The total number of crossings identified in this report is based on the latest LBA CCS new pipeline field layout [Ref.4] and approaches layout [Ref.9] to [Ref.12]. Table 4-4 and Table 4-5 presented below provide crossing details for the new future pipelines and spools at Douglas CCS approach respectively.

| Crossing No. | LBA CCS Pipelines | Pipeline/Cable to be Crossed | Crossed Pipeline/Cable Installation Status |
|---|---|---|---|
| 1 | New 16in Future Pipeline from Douglas CCS Platform to Lennox Platform | New Power Cable to Hamilton North | Yet to be installed; Assumed to be buried before pipeline installation. Proposed Min. 2.0m to Top of Pipe |

| Crossing No. | LBA CCS Pipelines | Pipeline/Cable to be Crossed | Crossed Pipeline/Cable Installation Status |
|---|---|---|---|
| 2 | | Existing Power Cable to Hamilton North | Buried |
| 3 | | Existing 14-inch Gas Export Pipeline PL1041 + 2-inch methanol PL1042 piggyback from Hamilton North to Douglas | Assumed exposed and concrete mattress protected |
| 4 | | Existing 8-inch Production PL2939 from Douglas to Conway Platform | Buried to 0.8m depth |
| 5 | | 3-inch Condensate PL2941 Piggyback from Douglas to Conway Platform | |
| 6 | | Existing 8-inch Water Injection PL2940 Pipeline from Douglas to Conway Platform | |
| 7 | | Existing 14-inch Oil Export PL1031 Pipeline from Douglas to Offshore Loading Unit | Buried to 0.8m depth |
| 8 | New 12in Future Pipeline from Douglas CCS Platform to Hamilton North | Existing 8-inch Production PL2939 from Douglas to Conway Platform | Buried to 0.8m depth |
| 9 | | 3-inch Condensate PL2941 Piggyback from Douglas to Conway Platform | |
| 10 | | Existing 8-inch Water Injection PL2940 from Douglas to Conway Platform | |
| 11 | | Existing 14-inch Oil Export Pipeline PL1031 from Douglas to Offshore Loading Unit | Buried to 0.8m depth |
| - | New 16in Future Pipeline from Douglas CCS Platform to Hamilton Main | No Crossing | |

**Table 4-4 Summary of Crossings for the LBA CCS New Future Pipelines**

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| Crossing No. | LBA CCS Spools | Pipeline/Cable to be Crossed | Crossed Pipeline/Cable Installation Status |
|---|---|---|---|
| 1a | 14” Spool (PL1041) – Douglas CCS to Hamilton North | Existing 14” (PL1031) Oil Export to OSI | Assumed exposed and concrete mattress protected |

| Crossing No. | LBA CCS Spools | Pipeline/Cable to be Crossed | Crossed Pipeline/Cable Installation Status |
|---|---|---|---|
| 2a | 16" Spool (PL1035) – Douglas CCS to Lennox | Existing 14" (PL1031) Oil Export to OSI | Assumed exposed and concrete mattress protected |
| 3a | 20" Spool (PL1039) – Douglas CCS to Hamilton Main | Existing 14" (PL1031) Oil Export to OSI | Assumed exposed and concrete mattress protected |
| 4a | 12" Spool (PL1036A) – Douglas CCS to Lennox | Existing 14" (PL1031) Oil Export to OSI | Assumed exposed and concrete mattress protected |
| 5a | 16" Spool – New Future Douglas CCS to Hamilton Main | Existing 14" (PL1031) Oil Export to OSI | Assumed exposed and concrete mattress protected |

**Table 4-5 Summary of Crossings for the LBA CCS New Spools at Douglas CCS Approach**

## 4.2 Recommendation

1. All the new future pipelines and cables routing should be reviewed with respect to any additional or future survey information to accurately confirm number of crossings.
2. Use of either mattresses or rock-dump to be finalised based on the final pipeline protection report [Ref.6] before crossing design is undertaken.

## 5.0 CROSSING IDENTIFICATION

### 5.1 Crossings

The new future pipelines and spools crossings for LBA CCS project are detailed below [Ref.4].

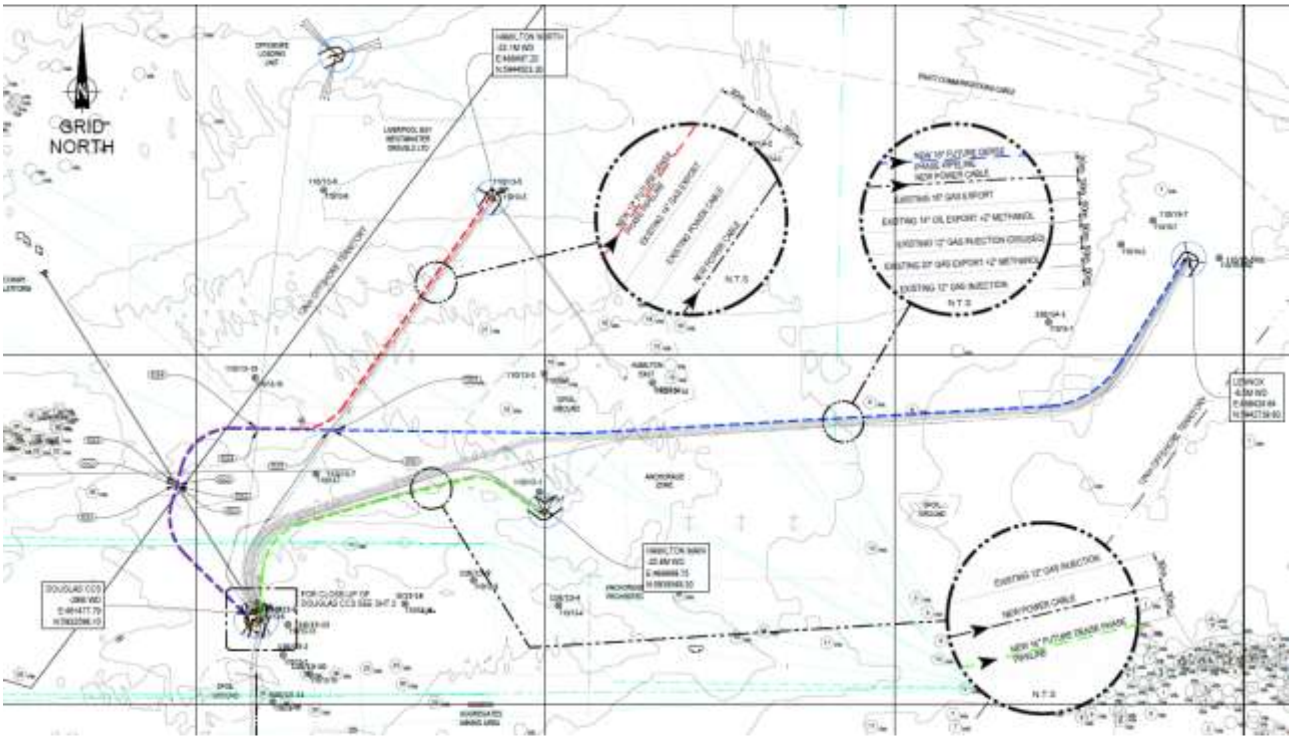


**Figure 5-1 – Crossings identified on the Pipeline layout**

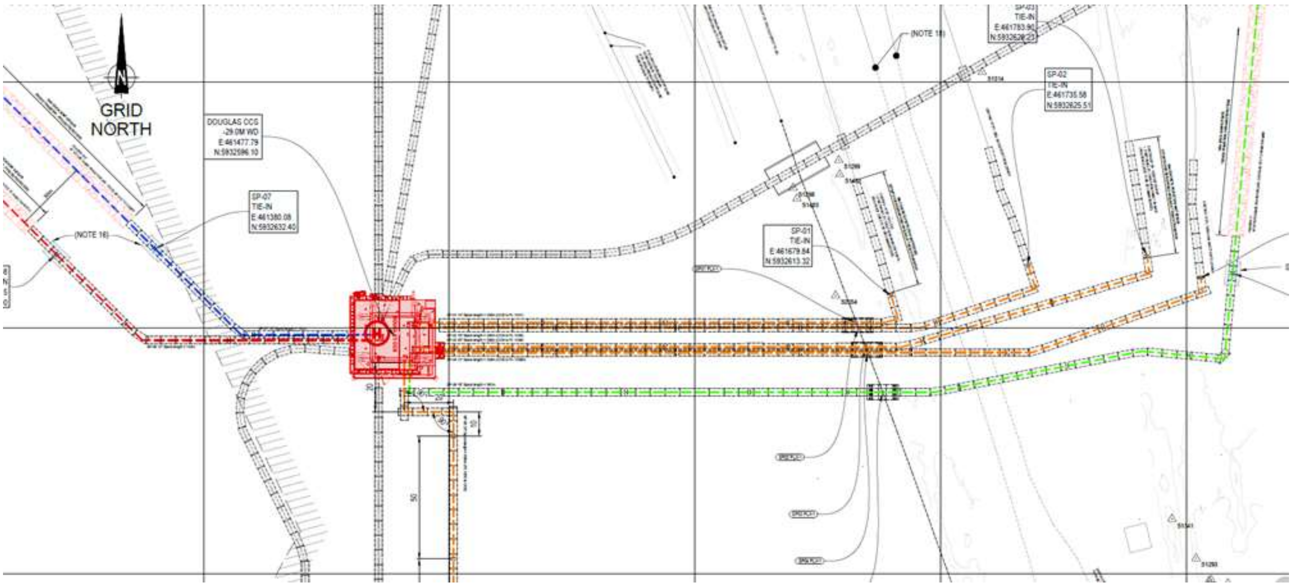


**Figure 5-2 – Crossings identified on the Spool layout at Douglas CCS**

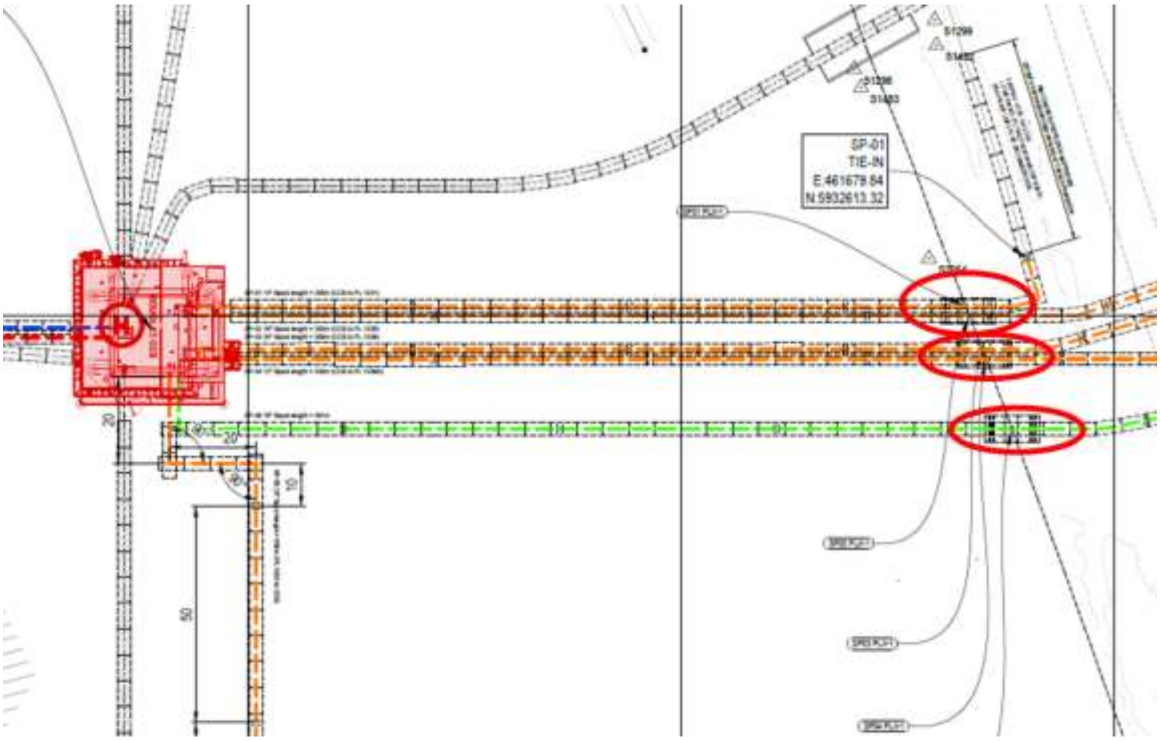

**Figure 5-3 – Crossings identified on existing PL1031 at Douglas CCS**

### 5.1.1 New 16in Future Pipeline from Douglas CCS Platform to Lennox Platform

The new 16-inch future pipeline crosses over 5 existing pipelines, 1 existing and 1 new proposed power cable for the LBA CCS project [Ref.4]. Table 5-1 below presents the list of the pipeline crossings:

| Crossing ID | Pipeline/Cable to be Crossed | UTM Coordinates | | Water Depth (approx.) | Asset Owner / Operator |
|---|---|---|---|---|---|
| | | Easting | Northing | | |
| PLX-1 | 8in (PL2939) Production to CONWY | 459461.72 | 5936244.25 | 26m | Eni UK |
| PLX-2 | 3in (PL2941) Condensate to CONWY | 459461.83 | 5936244.68 | 26m | |
| PLX-3 | 8in (PL2940) Water Injection to CONWY | 459472.17 | 5936282.10 | 26m | |
| PLX-4 | 14in Oil Export (PL1031) to OLU | 461769.69 | 5937872.15 | 30m | |
| PLX-5 | 14in Gas Export (PL1041) + 2in Methanol (PL1042) from Hamilton North | 463854.82 | 5937844.24 | 28m | |
| FOX-1 | Existing Power cable to Hamilton North | 463898.13 | 5937843.66 | 28m | |

| Crossing ID | Pipeline/Cable to be Crossed | UTM Coordinates | | Water Depth (approx.) | Asset Owner / Operator |
|---|---|---|---|---|---|
| | | Easting | Northing | | |
| FOX-2 | New Power Cable to Hamilton North | 464014.97 | 5937842.10 | 28m | |

**Table 5-1 Identified Crossing Details of New 16in Future Pipeline (Douglas CCS to Lennox)**

### 5.1.2 New 12in Future Pipeline from Douglas Platform to Hamilton North Platform

The new 12-inch future pipeline crosses over 3 existing pipelines from Douglas CCS platform to Conwy Platform and 1 pipeline from Douglas CCS platform to offloading unit [Ref.4]. Table 5-2 below presents the list of the pipeline crossings:

| Crossing ID | Pipeline/Cable to be Crossed | UTM Coordinates | | Water Depth (approx.) | Asset Owner / Operator |
|---|---|---|---|---|---|
| | | Easting | Northing | | |
| PLX-1 | 8in (PL2939) Production to CONWY | 459440.10 | 5936278.67 | 26m | Eni UK |
| PLX-2 | 3in (PL2941) Condensate to CONWY | 459440.22 | 5936279.10 | 26m | |
| PLX-3 | 8in (PL2940) Water Injection to CONWY | 459450.55 | 5936316.52 | 26m | |
| PLX-4 | 14in Oil Export (PL1031) to OLU | 461771.97 | 5937902.12 | 30m | |

**Table 5-2 Identified Crossing Details of New 12in Future Pipeline (Douglas CCS to Hamilton North)**

### 5.1.3 New 16in Future Pipeline from Douglas CCS Platform to Hamilton Main Platform

There are no pipelines and cables crossing identified along the new 16in future pipeline route from Douglas CCS platform to Hamilton main platform [Ref.4].

### 5.1.4 14in PL1041 Spool - Douglas CCS Platform to Hamilton North

The PL1041 spool crosses over existing PL1031. Table 5-3 below presents crossing details [Ref.4]

| Crossing ID | Pipeline/Cable to be Crossed | UTM Coordinates | | Water Depth (approx.) | Asset Owner / Operator |
|---|---|---|---|---|---|
| | | Easting | Northing | | |
| PLX-1-01 | 14in Oil Export (PL1031) to OSI | 461665.70 | 5932602.20 | 29m | Eni UK |

**Table 5-3 Identified Crossing Details of PL1041 Spool**

#### 5.1.5 16in PL1035 Spool - Douglas CCS Platform to Lennox

The PL1035 spool crosses over existing PL1031. Table 5-4 below presents crossing details [Ref.4]

| Crossing ID | Pipeline/Cable to be Crossed | UTM Coordinates | | Water Depth (approx.) | Asset Owner / Operator |
|---|---|---|---|---|---|
| | | Easting | Northing | | |
| PLX-1-02 | 14in Oil Export (PL1031) to OSI | 461666.54 | 5932600.00 | 29m | Eni UK |

**Table 5-4 Identified Crossing Details of PL1035 Spool**

#### 5.1.6 20in PL1039 Spool – Douglas CCS to Hamilton Main

The PL1039 spool crosses over existing PL1031. Table 5-5 below presents crossing details [Ref.4]

| Crossing ID | Pipeline/Cable to be Crossed | UTM Coordinates | | Water Depth (approx.) | Asset Owner / Operator |
|---|---|---|---|---|---|
| | | Easting | Northing | | |
| PLX-1-03 | 14in Oil Export (PL1031) to OSI | 461669.51 | 5932592.21 | 29m | Eni UK |

**Table 5-5 Identified Crossing Details of PL1039 Spool**

#### 5.1.7 12in PL1036A Spool – Douglas CCS to Lennox

The PL1036A spool crosses over existing PL1031. Table 5-6 below presents crossing details [Ref.4]

| Crossing ID | Pipeline/Cable to be Crossed | UTM Coordinates | | Water Depth (approx.) | Asset Owner / Operator |
|---|---|---|---|---|---|
| | | Easting | Northing | | |
| PLX-1-04 | 14in Oil Export (PL1031) to OSI | 461670.34 | 5932590.01 | 28m | Eni UK |

**Table 5-6 Identified Crossing Details of PL1036A Spool**

#### 5.1.8 Spool for Douglas CCS Platform to New Future Pipeline to Hamilton Main

The New Future 16in Pipeline to Hamilton Main spool crosses over existing PL1031. Table 5-7 presents crossing details [Ref.4].

| Crossing ID | Pipeline/Cable to be Crossed | UTM Coordinates | | Water Depth (approx.) | Asset Owner / Operator |
|---|---|---|---|---|---|
| | | Easting | Northing | | |
| PLX-1-06 | 14in Oil Export (PL1031) to OSI | 461676.37 | 5932573.90 | 28m | Eni UK |

**Table 5-7 Identified Crossing Details of Spool – Spool for Douglas CCS to New Future 16in pipeline to Hamilton Main**

## 6.0 CROSSING CRITERIA

Criteria for crossing of existing pipelines and cables shall be mutually agreed with the OWNER of the system to be crossed.

The following general criteria apply:

- A minimum separation distance of 0.5m shall be guaranteed for the entire design life of the systems involved.
- Potential settlement of the crossing intervention works shall be evaluated during the overall design life in order to guarantee the minimum separation distance.
- Integrity of existing systems shall be guaranteed and applied loads shall be minimised.
- Crossing shall be at right angle as possible. Crossing angles lower than 40deg shall be avoided unless specific circumstances make it unfeasible (e.g. very narrow corridors, prohibitive extra route length, etc.).

Crossing of existing systems shall be based on a conventional solution to guarantee a physical separation with the facilities to be crossed. The material used for the supports shall generally avoid damages to the pipeline coatings and allow a re-distribution of point loads over wide contact areas. Pipeline support systems typically consist of gravel berms, bitumen mattresses, and sand/grout bags. For deep water applications the opportunity to use concrete/steel sleepers should be investigated provided that no coating damage and excessive stress concentration effect are foreseen.

Potential interference with the cathodic protection systems shall be duly considered.

### 6.1 Pipeline Crossing Design Requirements

The pipeline crossing design shall, as a minimum, address:

- Requirements from the Owner of the system being crossed.
- Pipeline stability at crossing locations including check of possible uplifts.
- Stresses and free spans to remain within acceptable limits under all design conditions.
- Stability of supports including check of short/long term geotechnical stability and consolidation settlements, definition of stable rock size with respect to hydrodynamic loads.
- Proper sizing of supports with due account of pipelay tolerances, support positioning tolerances and crossing angle.
- Risk of interference of suspended span with fishing gears and definition of pipeline protection measures, if required.
- Avoid that the existing line is overloaded by the new line or crossing protection.
- Permit to recover the existing pipeline or cable. Plan the crossing in the area where no free spans are present in the existing line.
- Protect the entire crossing by using mattresses or gravel in case of fishing/pipeline interaction study require it.
- Crossing of cables/umbilicals in deep water shall be optimised minimising the installation of large amount of materials like mattresses, gravel dumping, etc. When possible, crossing shall be proposed by post trenching the existing cable/umbilical following the approval of the related owner.
- 25-year design life
- The proposed crossing design must not have any detrimental effect of the operational life of the pipeline that it is protecting.
- The design must be compliant with the requirements of the crossing agreement.

During the design, in case of a third party will cross an existing pipeline owned by COMPANY or vice versa, a proper dossier shall be prepared for the crossing proposal to be submitted sufficiently in advance for the approval of the owner of facilities to be crossed.

## 7.0 INPUT DATA

### 7.1 Pipeline and Spool Data

The pipeline mechanical data is presented in the table below [Ref.21]:

| Parameters | Units | New 16in Future Pipeline Douglas CSS to Hamilton Main | New 12in Future Pipeline Douglas CSS to Hamilton North | New 16in Future Pipeline Douglas CSS to Lennox |
|---|---|---|---|---|
| Nominal Pipeline Diameter | [in] | 16 | 12 | 16 |
| Line Pipe | - | CS | CS | CS |
| Clad Layer | [-] | No | No | No |
| Outside Diameter (constant) | [mm] | 406.4 | 323.8 | 406.4 |
| Inside Diameter | [mm] | 374.64 | 298.4 | 374.64 |
| Wall Thickness | [mm] | 15.88 | 12.7 | 15.88 |
| Pipe Manufacturing | - | SMLS | SMLS | SMLS |
| Steel Grade | - | X65 | X65 | X65 |
| Specified Minimum Yield Strength (SMYS) | [MPa] | 448 | 448 | 448 |
| Specified Minimum Tensile Strength (SMTS) | [Mpa] | 530 | 530 | 530 |
| Carbon Steel Density | [kg/m$^3$] | 7850 | 7850 | 7850 |
| Carbon Steel Modulus of Elasticity | [Mpa] | 207000 | 207000 | 207000 |
| Carbon Steel Poisson's Ratio | - | 0.3 | 0.3 | 0.3 |
| Corrosion Allowance | [mm] | 3.0 | 3.0 | 3.0 |
| Anticorrosion coating | - | 3.5 | 3.1 | 3.5 |
| Anticorrosion coating density | [kg/m$^3$] | 930 | 930 | 930 |

**Table 7-1: Pipeline Mechanical and Geometrical Data**

Table 7-2 summarises the new spools mechanical data [Ref.21].

| Parameters | Units | 14in New Spool for PL1041 Douglas to Hamilton North | New 16in Spool for PL1035 Douglas to Lennox | New 20in Spool for PL1039 Douglas to Hamilton Main | 12in New Spool for PL1036A Douglas to Lennox |
|---|---|---|---|---|---|
| Nominal Spool Diameter | [in] | 14 | 16 | 20 | 12 |
| Line Pipe | - | Carbon Steel | Carbon Steel | Carbon Steel | Carbon Steel |
| Clad Layer | [-] | No | No | No | No |
| Outside Diameter (constant) | [mm] | 355.6 | 406.4 | 508.0 | 323.9 |
| Wall Thickness | [mm] | 14.27 | 15.88 | 19.05 | 12.7 |
| Pipe Manufacturing | - | SMLS | SMLS | SAWL | SMLS |
| Steel Grade | - | API 5L X65 | API 5L X65 | API 5L X65 | API 5L X65 |
| Specified Minimum Yield Strength (SMYS) | [MPa] | 448 | 448 | 448 | 448 |
| Specified Minimum Tensile Strength (SMTS) | [MPa] | 530 | 530 | 530 | 530 |
| Carbon Steel Density | [kg/m $^3$] | 7850 | 7850 | 7850 | 7850 |
| Carbon Steel Modulus of Elasticity | [MPa] | 207000 | 207000 | 207000 | 207000 |
| Carbon Steel Poisson's Ratio | - | 0.3 | 0.3 | 0.3 | 0.3 |
| Coefficient of Linear Thermal Expansion | [1 / °C] | $1.17 \times 10^{-5}$ | $1.17 \times 10^{-5}$ | $1.17 \times 10^{-5}$ | $1.17 \times 10^{-5}$ |
| Line Pipe Wall Thickness Fabrication Tolerance | [-] | ±12.5% | ±12.5% | ±1mm | ±12.5% |
| Corrosion Allowance | [mm] | 3.0 | 3.0 | 3.0 | 3.0 |
| Anticorrosion Coating Type | - | 3LPE | 3LPE | 3LPE | 3LPE |
| Anticorrosion Thickness | [mm] | 3.5 | 3.5 | 3.5 | 3.1 |
| Anticorrosion Coating Density | [kg/m $^3$] | 930 | 930 | 930 | 930 |

**Table 7-2 - Spool Mechanical and Geometrical Data**

### 7.2 Concrete Weight Coating Properties

Concrete Coating data for new lines have been extracted from [Ref.3]

| Parameter | Unit | New 16in Future Pipeline | New 12in Future Pipeline | New 16in Future Pipeline |
|---|---|---|---|---|
| | | Douglas CCS | Douglas CCS | Douglas CCS |
| | | Hamilton Main | Hamilton North | Lenox |
| Typical Concrete Coating Density | kg/m $^3$ | 3040 | 3040 | 3040 |

**Table 7-3 – Concrete Coating Properties for new Offshore Pipelines**

Concrete Coating thickness for new lines have been extracted from [Ref.6]

| Parameter | Unit | New future 16in New Pipeline | New future 12in New Pipeline | New future 16in New Pipeline |
|---|---|---|---|---|
| | | Douglas CCS to Hamilton Main | Douglas CCS to Hamilton North | Douglas CCS to Lennox |
| | | Installed Empty | Installed Empty | Installed Flooded Pre-Trench |
| Concrete Coating Thickness | mm | 55 | 50 | 40 (KP 0.0 to 17.3)<br>65 (KP 17.3 to KP 33.3)<br>95 (KP 33.3 to End) |

**Table 7-4 – Concrete Coating Thickness for new pipelines**

## 7.3 Water Depth

Following table summarised maximum and minimum water depth along the pipeline route.

| Pipeline | Section | KP Note 1 | | Water Depth |
|---|---|---|---|---|
| | | from | to | Min. |
| | | [km] | [km] | [m] |
| New 16in Future Pipeline - New Douglas CCS to Hamilton Main | Zone 2<br>Douglas CCS Platform | 0 | 0.5 | 29 |
| | Zone 1 | 0.5 | 9.83 | 25 |
| | Zone 2<br>Hamilton Main Platform | 9.83 | 10.33 | 25 |
| Note 1: KP are approximate<br>Note 2: Water Depth is in LAT | | | | |

**Table 7-5 – Water Depth along the new 16in Future Pipeline – Douglas CCS to Hamilton Main**

| Pipeline | Section | KP Note 1 | | Water Depth |
|---|---|---|---|---|
| | | from | to | Min. |
| | | [km] | [km] | [m] |
| New 12in Future Pipeline Douglas CCS to Hamilton North | Zone 2<br>Douglas CCS Platform | 0 | 0.5 | 29 |
| | Zone 1 | 0.5 | 17.25 | 22 |
| | Zone 2<br>Hamilton North Platform | 17.25 | 17.75 | 22 |
| Note 1: KP are approximate<br>Note 2: Water Depth is in LAT | | | | |

**Table 7-6 – Water Depth along the new 12in Future Pipeline – Douglas CCS to Hamilton North**

| Pipeline | Section | KP Note 1 | | Water Depth |
|---|---|---|---|---|
| | | from | to | Min. |
| | | [km] | [km] | [m] |
| New 16in Future Pipeline Douglas CCS to Lennox | Zone 2<br>Douglas CCS Platform | 0 | 0.5 | 29 |
| | Zone 1 | 0.5 | 35.86 | 10 |
| | Zone 2<br>Lennox | 35.86 | 36.36 | 8.5 |
| Note 1: KP are approximate<br>Note 2: Water Depth is in LAT | | | | |

**Table 7-7 – Water Depth along the new 16in Future Pipeline – Douglas CCS to Lennox**

| Sea Surface Elevations (Tide and Surge) | Units | Hamilton North Field | Douglas Field | Hamilton Main Field | Lennox Field |
|---|---|---|---|---|---|
| Chart Datum | m | LAT | LAT | LAT | LAT |
| Highest Astronomical Tide (HAT) | m | 9.43 | 9.20 | 9.46 | 9.66 |
| Lowest Astronomical Tide (LAT) | m | 0.00 | 0.00 | 0.00 | 0.00 |
| Mean Sea Level (MSL) | m | 4.67 | 4.56 | 4.68 | 4.79 |
| 1 Year Surge | m | 1.01 | 0.98 | 1.02 | 1.08 |
| 10 Year Surge | m | 1.40 | 1.37 | 1.42 | 1.50 |
| 100 Year Storm Surge | m | 1.77 | 1.73 | 1.98 | 1.90 |

**Table 7-8 – Sea Water levels**

### 7.4 Waves Data

Following wave data has been taken from [Ref.21] and considered in the free span assessment.

### 7.4.1 Douglas Field

| Return Period | Hs | Tz | | | Tp | | | Tass | | | Hmax | Crest Height |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (lower) | (central) | (upper) | (lower) | (central) | (upper) | (lower) | (central) | (upper) | | |
| | (m) | (s) | (s) | (s) | (s) | (s) | (s) | (s) | (s) | (s) | (m) | (m) |
| **1-year** | | | | | | | | | | | | |
| N | 3.7 | 5.7 | 6.3 | 7.1 | 7.5 | 8.5 | 9.7 | 6.7 | 8.1 | 9.5 | 6.2 | 3.9 |
| NE | 2.5 | 4.7 | 5.2 | 5.8 | 6.2 | 7.0 | 8.0 | 5.5 | 6.7 | 7.8 | 4.3 | 2.7 |
| E | 2.2 | 4.4 | 4.8 | 5.4 | 5.7 | 6.5 | 7.4 | 5.1 | 6.1 | 7.2 | 3.8 | 2.4 |
| SE | 2.5 | 4.7 | 5.2 | 5.8 | 6.2 | 7.0 | 8.0 | 5.5 | 6.7 | 7.8 | 4.2 | 2.6 |
| S | 2.6 | 4.8 | 5.3 | 5.9 | 6.3 | 7.2 | 8.2 | 5.6 | 6.8 | 8.0 | 4.4 | 2.7 |
| SW | 3.5 | 5.5 | 6.1 | 6.9 | 7.3 | 8.2 | 9.4 | 6.5 | 7.8 | 9.2 | 6.0 | 3.7 |
| W | 4.9 | 6.6 | 7.2 | 8.1 | 8.6 | 9.7 | 11.1 | 7.6 | 9.2 | 10.8 | 8.2 | 5.1 |
| NW | 4.3 | 6.1 | 6.8 | 7.6 | 8.1 | 9.2 | 10.5 | 7.2 | 8.7 | 10.2 | 7.2 | 4.5 |
| **10-years** | | | | | | | | | | | | |
| N | 4.6 | 6.4 | 7.0 | 7.9 | 8.3 | 9.5 | 10.8 | 7.4 | 9.0 | 10.5 | 7.8 | 4.9 |
| NE | 3.2 | 5.3 | 5.8 | 6.6 | 6.9 | 7.8 | 8.9 | 6.1 | 7.4 | 8.7 | 5.4 | 3.4 |
| E | 2.8 | 5.0 | 5.5 | 6.1 | 6.5 | 7.4 | 8.5 | 5.8 | 7.0 | 8.3 | 4.8 | 3.0 |
| SE | 3.1 | 5.2 | 5.7 | 6.5 | 6.8 | 7.7 | 8.8 | 6.0 | 7.3 | 8.6 | 5.3 | 3.3 |
| S | 3.3 | 5.4 | 5.9 | 6.7 | 7.0 | 8.0 | 9.1 | 6.3 | 7.6 | 8.9 | 5.6 | 3.5 |
| SW | 4.5 | 6.3 | 6.9 | 7.8 | 8.2 | 9.3 | 10.6 | 7.3 | 8.8 | 10.4 | 7.6 | 4.7 |
| W | 6.2 | 7.4 | 8.1 | 9.1 | 9.6 | 10.9 | 12.5 | 8.6 | 10.4 | 12.2 | 10.4 | 6.5 |
| NW | 5.4 | 6.9 | 7.6 | 8.5 | 9.0 | 10.3 | 11.7 | 8.1 | 9.7 | 11.4 | 9.1 | 5.7 |
| **50-years** | | | | | | | | | | | | |
| N | 5.3 | 6.8 | 7.5 | 8.4 | 8.9 | 10.1 | 11.6 | 8.0 | 9.6 | 11.3 | 8.8 | 5.6 |
| NE | 3.6 | 5.6 | 6.2 | 7.0 | 7.4 | 8.4 | 9.5 | 6.6 | 7.9 | 9.3 | 6.2 | 3.8 |
| E | 3.2 | 5.3 | 5.8 | 6.6 | 6.9 | 7.8 | 8.9 | 6.1 | 7.4 | 8.7 | 5.5 | 3.4 |
| SE | 3.6 | 5.6 | 6.2 | 7.0 | 7.4 | 8.4 | 9.5 | 6.6 | 7.9 | 9.3 | 6.0 | 3.8 |
| S | 3.8 | 5.8 | 6.4 | 7.1 | 7.6 | 8.6 | 9.8 | 6.8 | 8.2 | 9.6 | 6.3 | 4.0 |
| SW | 5.1 | 6.7 | 7.4 | 8.3 | 8.8 | 10.0 | 11.4 | 7.8 | 9.5 | 11.1 | 8.6 | 5.4 |
| W | 7.0 | 7.8 | 8.6 | 9.7 | 10.2 | 11.6 | 13.2 | 9.1 | 11.0 | 12.9 | 11.9 | 7.4 |
| NW | 6.2 | 7.4 | 8.1 | 9.1 | 9.6 | 10.9 | 12.5 | 8.6 | 10.4 | 12.2 | 10.4 | 6.5 |

**Table 7-9. Extreme Waves Characteristics – Douglas Platform – Directional Data**

### 7.4.2 Hamilton Field

| Return Period | Hs | Tz | | | Tp | | | Tass | | | Hmax | Crest Height |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (lower) | (central) | (upper) | (lower) | (central) | (upper) | (lower) | (central) | (upper) | | |
| | (m) | (s) | (s) | (s) | (s) | (s) | (s) | (s) | (s) | (s) | (m) | (m) |
| **1-year** | | | | | | | | | | | | |
| N | 3.7 | 5.7 | 6.3 | 7.1 | 7.5 | 8.5 | 9.7 | 6.7 | 8.1 | 9.5 | 6.2 | 3.9 |
| NE | 2.5 | 4.7 | 5.2 | 5.8 | 6.2 | 7.0 | 8.0 | 5.5 | 6.7 | 7.6 | 4.3 | 2.7 |
| E | 2.2 | 4.4 | 4.8 | 5.4 | 5.7 | 6.5 | 7.4 | 5.1 | 6.1 | 7.2 | 3.8 | 2.4 |
| SE | 2.5 | 4.7 | 5.2 | 5.8 | 6.2 | 7.0 | 8.0 | 5.5 | 6.7 | 7.6 | 4.2 | 2.6 |
| S | 2.6 | 4.8 | 5.3 | 5.9 | 6.3 | 7.2 | 8.2 | 5.6 | 6.8 | 8.0 | 4.4 | 2.8 |
| SW | 3.5 | 5.5 | 6.1 | 6.9 | 7.3 | 8.2 | 9.4 | 6.5 | 7.8 | 9.2 | 6.0 | 3.8 |
| W | 4.8 | 6.6 | 7.2 | 8.1 | 8.6 | 9.7 | 11.1 | 7.6 | 9.2 | 10.8 | 8.3 | 5.2 |
| NW | 4.3 | 6.1 | 6.8 | 7.6 | 8.1 | 9.2 | 10.5 | 7.2 | 8.7 | 10.2 | 7.3 | 4.6 |
| **10-years** | | | | | | | | | | | | |
| N | 4.6 | 6.4 | 7.0 | 7.9 | 8.3 | 9.5 | 10.8 | 7.4 | 9.0 | 10.6 | 7.9 | 6.0 |
| NE | 3.2 | 5.3 | 5.8 | 6.6 | 6.9 | 7.8 | 8.8 | 6.1 | 7.4 | 8.7 | 5.4 | 3.4 |
| E | 2.8 | 5.0 | 5.5 | 6.1 | 6.5 | 7.4 | 8.5 | 5.8 | 7.0 | 8.3 | 4.8 | 3.0 |
| SE | 3.1 | 5.2 | 5.7 | 6.5 | 6.8 | 7.7 | 8.8 | 6.0 | 7.3 | 8.6 | 5.3 | 3.3 |
| S | 3.3 | 5.4 | 5.9 | 6.7 | 7.0 | 8.0 | 9.1 | 6.3 | 7.6 | 8.9 | 5.6 | 3.5 |
| SW | 4.5 | 6.3 | 6.9 | 7.8 | 8.2 | 9.3 | 10.6 | 7.3 | 8.8 | 10.4 | 7.6 | 4.8 |
| W | 6.2 | 7.4 | 8.1 | 9.1 | 9.6 | 10.9 | 12.5 | 8.6 | 10.4 | 12.2 | 10.5 | 6.6 |
| NW | 5.4 | 6.9 | 7.6 | 8.5 | 9.0 | 10.3 | 11.7 | 8.1 | 9.7 | 11.4 | 9.2 | 5.8 |
| **50-years** | | | | | | | | | | | | |
| N | 5.3 | 6.8 | 7.5 | 8.4 | 8.9 | 10.1 | 11.8 | 8.0 | 9.6 | 11.3 | 9.0 | 5.7 |
| NE | 3.6 | 5.6 | 6.2 | 7.0 | 7.4 | 8.4 | 9.5 | 6.6 | 7.9 | 9.3 | 6.2 | 3.9 |
| E | 3.2 | 5.3 | 5.8 | 6.6 | 6.9 | 7.8 | 8.8 | 6.1 | 7.4 | 8.7 | 5.5 | 3.4 |
| SE | 3.6 | 5.6 | 6.2 | 7.0 | 7.4 | 8.4 | 9.5 | 6.6 | 7.9 | 9.3 | 6.1 | 3.8 |
| S | 3.8 | 5.8 | 6.4 | 7.1 | 7.6 | 8.6 | 9.9 | 6.8 | 8.2 | 9.6 | 6.4 | 4.0 |
| SW | 5.1 | 6.7 | 7.4 | 8.3 | 8.8 | 10.0 | 11.4 | 7.8 | 9.5 | 11.1 | 8.7 | 5.5 |
| W | 7.0 | 7.8 | 8.6 | 9.7 | 10.2 | 11.6 | 13.2 | 9.1 | 11.0 | 12.9 | 12.0 | 7.5 |
| NW | 6.2 | 7.4 | 8.1 | 9.1 | 9.6 | 10.9 | 12.5 | 8.6 | 10.4 | 12.2 | 10.5 | 6.6 |

**Table 7-10. Extreme Waves Characteristics – Hamilton Platform – Directional Data**

### 7.4.3 Hamilton North Field

| Return Period | Hs | Tz | | | Tp | | | Tass | | | Hmax | Crest Height |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (lower) | (central) | (upper) | (lower) | (central) | (upper) | (lower) | (central) | (upper) | | |
| | (m) | (s) | (s) | (s) | (s) | (s) | (s) | (s) | (s) | (s) | (m) | (m) |
| 1-year | | | | | | | | | | | | |
| N | 3.8 | 5.8 | 6.4 | 7.1 | 7.6 | 8.6 | 9.9 | 6.8 | 8.2 | 9.6 | 6.3 | 4.0 |
| NE | 2.6 | 4.8 | 5.3 | 5.9 | 6.3 | 7.2 | 8.2 | 5.6 | 6.8 | 8.0 | 4.4 | 2.7 |
| E | 2.3 | 4.5 | 4.9 | 5.6 | 5.8 | 6.6 | 7.5 | 5.2 | 6.3 | 7.4 | 3.9 | 2.4 |
| SE | 2.5 | 4.7 | 5.2 | 5.8 | 6.2 | 7.0 | 8.0 | 5.5 | 6.7 | 7.8 | 4.3 | 2.7 |
| S | 2.7 | 4.9 | 5.4 | 6.0 | 6.4 | 7.3 | 8.3 | 5.7 | 6.9 | 8.1 | 4.5 | 2.8 |
| SW | 3.6 | 5.6 | 6.2 | 7.0 | 7.4 | 8.4 | 9.5 | 6.6 | 7.9 | 9.3 | 6.1 | 3.8 |
| W | 5.0 | 6.6 | 7.3 | 8.2 | 8.7 | 9.9 | 11.2 | 7.7 | 9.3 | 11.0 | 8.4 | 5.3 |
| NW | 4.4 | 6.2 | 6.8 | 7.7 | 8.1 | 9.2 | 10.5 | 7.2 | 8.7 | 10.2 | 7.4 | 4.6 |
| 10-years | | | | | | | | | | | | |
| N | 4.8 | 6.5 | 7.1 | 8.0 | 8.4 | 9.6 | 10.9 | 7.5 | 9.1 | 10.7 | 8.0 | 5.0 |
| NE | 3.3 | 5.4 | 5.9 | 6.7 | 7.0 | 8.0 | 9.1 | 6.3 | 7.6 | 8.9 | 5.5 | 3.5 |
| E | 2.9 | 5.0 | 5.6 | 6.2 | 6.7 | 7.6 | 8.6 | 5.9 | 7.2 | 8.4 | 4.9 | 3.1 |
| SE | 3.2 | 5.3 | 5.8 | 6.6 | 6.9 | 7.8 | 8.9 | 6.1 | 7.4 | 8.7 | 5.4 | 3.4 |
| S | 3.4 | 5.5 | 6.0 | 6.8 | 7.1 | 8.1 | 9.2 | 6.4 | 7.7 | 9.0 | 5.7 | 3.6 |
| SW | 4.6 | 6.4 | 7.0 | 7.8 | 8.3 | 9.5 | 10.8 | 7.4 | 9.0 | 10.5 | 7.8 | 4.8 |
| W | 6.3 | 7.4 | 8.2 | 9.2 | 9.8 | 11.1 | 12.6 | 8.7 | 10.5 | 12.3 | 10.7 | 6.7 |
| NW | 5.8 | 7.0 | 7.7 | 8.7 | 9.2 | 10.4 | 11.8 | 8.2 | 9.9 | 11.6 | 9.4 | 5.9 |
| 50-years | | | | | | | | | | | | |
| N | 5.4 | 6.9 | 7.6 | 8.5 | 9.0 | 10.3 | 11.7 | 8.1 | 9.7 | 11.4 | 9.2 | 5.7 |
| NE | 3.7 | 5.7 | 6.3 | 7.1 | 7.5 | 8.5 | 9.7 | 6.7 | 8.1 | 9.5 | 6.3 | 3.9 |
| E | 3.3 | 5.4 | 5.9 | 6.7 | 7.0 | 8.0 | 9.1 | 6.3 | 7.6 | 8.9 | 5.6 | 3.5 |
| SE | 3.7 | 5.7 | 6.3 | 7.1 | 7.5 | 8.5 | 9.7 | 6.7 | 8.1 | 9.5 | 6.2 | 3.9 |
| S | 3.9 | 5.8 | 6.4 | 7.2 | 7.6 | 8.6 | 9.9 | 6.8 | 8.2 | 9.6 | 6.5 | 4.1 |
| SW | 5.2 | 6.8 | 7.4 | 8.4 | 8.8 | 10.0 | 11.4 | 7.8 | 9.5 | 11.1 | 8.8 | 5.5 |
| W | 7.2 | 7.9 | 8.7 | 9.8 | 10.4 | 11.7 | 13.4 | 9.2 | 11.1 | 13.1 | 12.2 | 7.6 |
| NW | 6.3 | 7.4 | 8.2 | 9.2 | 9.8 | 11.1 | 12.6 | 8.7 | 10.5 | 12.3 | 10.7 | 6.7 |

**Table 7-11. Extreme Waves Characteristics – Hamilton North Platform – Directional Data**

### 7.4.4 Lennox Field

| Return Period | Hs | Tz | | | Tp | | | Tass | | | Hmax | Crest Height |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (lower) | (central) | (upper) | (lower) | (central) | (upper) | (lower) | (central) | (upper) | | |
| | (m) | (s) | (s) | (s) | (s) | (s) | (s) | (s) | (s) | (s) | (m) | (m) |
| 1-year | | | | | | | | | | | | |
| N | 3.5 | 5.5 | 6.1 | 6.9 | 7.3 | 8.2 | 9.4 | 6.5 | 7.8 | 9.2 | 6.5 | 4.5 |
| NE | 2.1 | 4.3 | 4.7 | 5.3 | 5.8 | 6.3 | 7.2 | 5.0 | 6.0 | 7.1 | 3.9 | 2.7 |
| E | 1.4 | 3.5 | 3.9 | 4.3 | 4.6 | 5.3 | 6.0 | 4.1 | 5.0 | 5.9 | 2.6 | 1.8 |
| SE | 1.8 | 4.0 | 4.4 | 4.9 | 5.2 | 5.9 | 6.8 | 4.7 | 5.6 | 6.6 | 3.4 | 2.3 |
| S | 2.8 | 5.0 | 5.5 | 6.1 | 6.5 | 7.4 | 8.5 | 5.8 | 7.0 | 8.3 | 5.2 | 3.6 |
| SW | 3.9 | 5.8 | 6.4 | 7.2 | 7.6 | 8.6 | 9.9 | 6.8 | 8.2 | 9.6 | 7.3 | 5.0 |
| W | 5.1 | 6.7 | 7.4 | 8.3 | 8.8 | 10.0 | 11.4 | 7.8 | 9.5 | 11.1 | 9.5 | 6.8 |
| NW | 4.4 | 6.2 | 6.8 | 7.7 | 8.1 | 9.2 | 10.5 | 7.2 | 8.7 | 10.2 | 8.2 | 5.7 |
| 10-years | | | | | | | | | | | | |
| N | 4.0 | 5.9 | 6.5 | 7.3 | 7.7 | 8.8 | 10.0 | 6.9 | 8.3 | 9.8 | 7.4 | 5.5 |
| NE | 2.5 | 4.7 | 5.2 | 5.8 | 6.2 | 7.0 | 8.0 | 5.5 | 6.7 | 7.8 | 4.6 | 3.4 |
| E | 1.7 | 3.9 | 4.3 | 4.8 | 5.1 | 5.8 | 6.6 | 4.6 | 5.5 | 6.5 | 3.1 | 2.3 |
| SE | 2.2 | 4.4 | 4.8 | 5.4 | 5.7 | 6.5 | 7.4 | 5.1 | 6.1 | 7.2 | 4.1 | 3.0 |
| S | 3.1 | 5.2 | 5.7 | 6.5 | 6.8 | 7.7 | 8.8 | 6.0 | 7.3 | 8.6 | 5.7 | 4.3 |
| SW | 4.7 | 6.4 | 7.1 | 8.0 | 8.4 | 9.6 | 10.9 | 7.5 | 9.1 | 10.7 | 8.7 | 6.5 |
| W | 6.1 | 7.3 | 8.1 | 9.1 | 9.6 | 10.9 | 12.5 | 8.6 | 10.4 | 12.2 | 11.3 | 8.4 |
| NW | 5.4 | 6.9 | 7.6 | 8.5 | 9.0 | 10.3 | 11.7 | 8.1 | 9.7 | 11.4 | 10.0 | 7.4 |
| 50-years | | | | | | | | | | | | |
| N | 4.5 | 6.3 | 6.9 | 7.8 | 8.2 | 9.3 | 10.6 | 7.3 | 8.8 | 10.4 | 8.4 | 6.4 |
| NE | 2.8 | 5.0 | 5.5 | 6.1 | 6.5 | 7.4 | 8.5 | 5.8 | 7.0 | 8.3 | 5.2 | 4.0 |
| E | 1.9 | 4.1 | 4.5 | 5.1 | 5.4 | 6.1 | 6.9 | 4.8 | 5.8 | 6.8 | 3.5 | 2.7 |
| SE | 2.2 | 4.4 | 4.8 | 5.4 | 5.7 | 6.5 | 7.4 | 5.1 | 6.1 | 7.2 | 4.1 | 3.1 |
| S | 3.1 | 5.2 | 5.7 | 6.5 | 6.8 | 7.7 | 8.8 | 6.0 | 7.3 | 8.6 | 5.8 | 4.4 |
| SW | 5.1 | 6.7 | 7.4 | 8.3 | 8.8 | 10.0 | 11.4 | 7.8 | 9.5 | 11.1 | 9.5 | 7.2 |
| W | 6.5 | 7.6 | 8.3 | 9.4 | 9.9 | 11.2 | 12.8 | 8.8 | 10.6 | 12.5 | 12.1 | 9.2 |
| NW | 6.0 | 7.3 | 8.0 | 9.0 | 9.5 | 10.8 | 12.3 | 8.5 | 10.2 | 12.0 | 11.2 | 8.5 |

**Table 7-12. Extreme Waves Characteristics – Lennox Platform – Directional Data**

### 7.5 Currents Data

Following current data has been taken from [Ref.21] and considered in the free span assessment.

#### 7.5.1 Douglas Field

| Height (asb)/ Depth Ratio] | N | NE | E | SE | S | SW | W | NW | Omni |
|---|---|---|---|---|---|---|---|---|---|
| **1 Year** | m/s | m/s | m/s | m/s | m/s | m/s | m/s | m/s | m/s |
| Surface | 0.18 | 0.35 | 0.99 | 0.31 | 0.16 | 0.26 | 0.81 | 0.33 | 0.99 |
| 75% of Water Depth | 0.18 | 0.35 | 0.99 | 0.31 | 0.16 | 0.26 | 0.81 | 0.33 | 0.99 |
| 50% of Water Depth | 0.18 | 0.35 | 0.99 | 0.31 | 0.16 | 0.26 | 0.81 | 0.33 | 0.99 |
| 40% of Water Depth | 0.18 | 0.34 | 0.96 | 0.30 | 0.16 | 0.25 | 0.79 | 0.32 | 0.96 |
| 30% of Water Depth | 0.17 | 0.33 | 0.92 | 0.29 | 0.15 | 0.24 | 0.76 | 0.31 | 0.92 |
| 20% of Water Depth | 0.16 | 0.32 | 0.87 | 0.27 | 0.14 | 0.23 | 0.72 | 0.29 | 0.87 |
| 10% of Water Depth | 0.14 | 0.27 | 0.77 | 0.24 | 0.12 | 0.20 | 0.63 | 0.26 | 0.77 |
| 5% of Water Depth | 0.13 | 0.26 | 0.72 | 0.23 | 0.11 | 0.18 | 0.60 | 0.24 | 0.72 |
| Near Bed | 0.12 | 0.24 | 0.66 | 0.21 | 0.11 | 0.18 | 0.55 | 0.22 | 0.66 |
| **10 Years** | m/s | m/s | m/s | m/s | m/s | m/s | m/s | m/s | m/s |
| Surface | 0.19 | 0.38 | 1.06 | 0.33 | 0.17 | 0.28 | 0.87 | 0.35 | 1.06 |
| 75% of Water Depth | 0.19 | 0.38 | 1.06 | 0.33 | 0.17 | 0.28 | 0.87 | 0.35 | 1.06 |
| 50% of Water Depth | 0.19 | 0.38 | 1.06 | 0.33 | 0.17 | 0.28 | 0.87 | 0.35 | 1.06 |
| 40% of Water Depth | 0.19 | 0.37 | 1.04 | 0.32 | 0.17 | 0.27 | 0.86 | 0.34 | 1.04 |
| 30% of Water Depth | 0.18 | 0.36 | 0.99 | 0.31 | 0.16 | 0.26 | 0.82 | 0.33 | 0.99 |
| 20% of Water Depth | 0.17 | 0.34 | 0.94 | 0.29 | 0.15 | 0.25 | 0.78 | 0.31 | 0.94 |
| 10% of Water Depth | 0.15 | 0.29 | 0.83 | 0.26 | 0.13 | 0.22 | 0.68 | 0.28 | 0.83 |
| 5% of Water Depth | 0.14 | 0.29 | 0.78 | 0.25 | 0.12 | 0.20 | 0.65 | 0.26 | 0.78 |
| Near Bed | 0.13 | 0.26 | 0.71 | 0.23 | 0.11 | 0.19 | 0.59 | 0.24 | 0.71 |
| **50 Years** | m/s | m/s | m/s | m/s | m/s | m/s | m/s | m/s | m/s |
| Surface | 0.20 | 0.40 | 1.12 | 0.35 | 0.18 | 0.29 | 0.92 | 0.37 | 1.12 |
| 75% of Water Depth | 0.20 | 0.40 | 1.12 | 0.35 | 0.18 | 0.29 | 0.92 | 0.37 | 1.12 |
| 50% of Water Depth | 0.20 | 0.40 | 1.12 | 0.35 | 0.18 | 0.29 | 0.92 | 0.37 | 1.12 |
| 40% of Water Depth | 0.20 | 0.39 | 1.09 | 0.34 | 0.18 | 0.28 | 0.90 | 0.36 | 1.09 |
| 30% of Water Depth | 0.19 | 0.38 | 1.04 | 0.33 | 0.17 | 0.27 | 0.86 | 0.35 | 1.04 |
| 20% of Water Depth | 0.18 | 0.36 | 0.99 | 0.31 | 0.16 | 0.26 | 0.82 | 0.33 | 0.99 |
| 10% of Water Depth | 0.16 | 0.31 | 0.87 | 0.27 | 0.14 | 0.23 | 0.72 | 0.29 | 0.87 |
| 5% of Water Depth | 0.15 | 0.30 | 0.82 | 0.26 | 0.13 | 0.21 | 0.68 | 0.27 | 0.82 |
| Near Bed | 0.14 | 0.27 | 0.75 | 0.24 | 0.12 | 0.20 | 0.62 | 0.25 | 0.75 |
| **100 Years** | m/s | m/s | m/s | m/s | m/s | m/s | m/s | m/s | m/s |
| Surface | 0.20 | 0.41 | 1.14 | 0.36 | 0.18 | 0.30 | 0.94 | 0.38 | 1.14 |
| 75% of Water Depth | 0.20 | 0.41 | 1.14 | 0.36 | 0.18 | 0.30 | 0.94 | 0.38 | 1.14 |
| 50% of Water Depth | 0.20 | 0.41 | 1.14 | 0.36 | 0.18 | 0.30 | 0.94 | 0.38 | 1.14 |
| 40% of Water Depth | 0.20 | 0.40 | 1.11 | 0.35 | 0.18 | 0.29 | 0.92 | 0.37 | 1.11 |
| 30% of Water Depth | 0.19 | 0.39 | 1.06 | 0.34 | 0.17 | 0.28 | 0.88 | 0.36 | 1.06 |
| 20% of Water Depth | 0.18 | 0.37 | 1.01 | 0.32 | 0.16 | 0.27 | 0.84 | 0.34 | 1.01 |
| 10% of Water Depth | 0.16 | 0.32 | 0.89 | 0.28 | 0.14 | 0.23 | 0.73 | 0.30 | 0.89 |
| 5% of Water Depth | 0.15 | 0.31 | 0.84 | 0.27 | 0.13 | 0.21 | 0.69 | 0.28 | 0.84 |
| Near Bed | 0.14 | 0.28 | 0.77 | 0.24 | 0.12 | 0.20 | 0.63 | 0.26 | 0.77 |

**Table 7-13. Extreme Currents Characteristics – Douglas Platform – Directional Data**

### 7.5.2 Hamilton Field

| Height/Depth Ratio | North | Northeast | East | Southeast | South | Southwest | West | Northwest | Omni |
|---|---|---|---|---|---|---|---|---|---|
| **1 Year** | | | | | | | | | |
| Surface | 0.39 | 0.52 | 0.90 | 0.50 | 0.33 | 0.43 | 0.88 | 0.47 | 0.90 |
| 75% of Water Depth | 0.39 | 0.52 | 0.90 | 0.50 | 0.33 | 0.43 | 0.88 | 0.47 | 0.90 |
| 50% of Water Depth | 0.39 | 0.52 | 0.90 | 0.50 | 0.33 | 0.43 | 0.88 | 0.47 | 0.90 |
| 40% of Water Depth | 0.37 | 0.50 | 0.86 | 0.48 | 0.32 | 0.42 | 0.85 | 0.45 | 0.86 |
| 30% of Water Depth | 0.36 | 0.48 | 0.83 | 0.46 | 0.31 | 0.40 | 0.81 | 0.44 | 0.83 |
| 20% of Water Depth | 0.34 | 0.45 | 0.78 | 0.44 | 0.29 | 0.38 | 0.77 | 0.41 | 0.78 |
| 10% of Water Depth | 0.31 | 0.41 | 0.71 | 0.40 | 0.26 | 0.34 | 0.69 | 0.37 | 0.71 |
| 5% of Water Depth | 0.28 | 0.37 | 0.64 | 0.36 | 0.24 | 0.31 | 0.63 | 0.34 | 0.64 |
| 1m asb | 0.27 | 0.36 | 0.62 | 0.35 | 0.23 | 0.30 | 0.61 | 0.33 | 0.62 |
| | | | | | | | | | |
| **10 Years** | | | | | | | | | |
| Surface | 0.42 | 0.56 | 0.97 | 0.54 | 0.36 | 0.47 | 0.95 | 0.51 | 0.97 |
| 75% of Water Depth | 0.42 | 0.56 | 0.97 | 0.54 | 0.36 | 0.47 | 0.95 | 0.51 | 0.97 |
| 50% of Water Depth | 0.42 | 0.56 | 0.97 | 0.54 | 0.36 | 0.47 | 0.95 | 0.51 | 0.97 |
| 40% of Water Depth | 0.40 | 0.54 | 0.93 | 0.52 | 0.34 | 0.45 | 0.91 | 0.49 | 0.93 |
| 30% of Water Depth | 0.39 | 0.52 | 0.90 | 0.50 | 0.33 | 0.43 | 0.88 | 0.47 | 0.90 |
| 20% of Water Depth | 0.36 | 0.49 | 0.84 | 0.47 | 0.31 | 0.41 | 0.83 | 0.44 | 0.84 |
| 10% of Water Depth | 0.33 | 0.44 | 0.77 | 0.43 | 0.28 | 0.37 | 0.75 | 0.40 | 0.77 |
| 5% of Water Depth | 0.30 | 0.40 | 0.69 | 0.39 | 0.26 | 0.34 | 0.68 | 0.36 | 0.69 |
| 1m asb | 0.29 | 0.39 | 0.67 | 0.37 | 0.25 | 0.32 | 0.65 | 0.35 | 0.67 |
| | | | | | | | | | |
| **50 Years** | | | | | | | | | |
| Surface | 0.44 | 0.59 | 1.02 | 0.57 | 0.37 | 0.49 | 1.00 | 0.54 | 1.02 |
| 75% of Water Depth | 0.44 | 0.59 | 1.02 | 0.57 | 0.37 | 0.49 | 1.00 | 0.54 | 1.02 |
| 50% of Water Depth | 0.44 | 0.59 | 1.02 | 0.57 | 0.37 | 0.49 | 1.00 | 0.54 | 1.02 |
| 40% of Water Depth | 0.42 | 0.57 | 0.98 | 0.55 | 0.36 | 0.48 | 0.96 | 0.52 | 0.98 |
| 30% of Water Depth | 0.41 | 0.55 | 0.94 | 0.53 | 0.35 | 0.46 | 0.92 | 0.50 | 0.94 |
| 20% of Water Depth | 0.38 | 0.51 | 0.89 | 0.50 | 0.33 | 0.43 | 0.87 | 0.47 | 0.89 |
| 10% of Water Depth | 0.35 | 0.47 | 0.81 | 0.45 | 0.30 | 0.39 | 0.79 | 0.42 | 0.81 |
| 5% of Water Depth | 0.31 | 0.42 | 0.73 | 0.41 | 0.27 | 0.35 | 0.71 | 0.38 | 0.73 |
| 1m asb | 0.30 | 0.41 | 0.70 | 0.39 | 0.26 | 0.34 | 0.69 | 0.37 | 0.70 |
| | | | | | | | | | |
| **100 Years** | | | | | | | | | |
| Surface | 0.45 | 0.60 | 1.04 | 0.58 | 0.38 | 0.50 | 1.02 | 0.55 | 1.04 |
| 75% of Water Depth | 0.45 | 0.60 | 1.04 | 0.58 | 0.38 | 0.50 | 1.02 | 0.55 | 1.04 |
| 50% of Water Depth | 0.45 | 0.60 | 1.04 | 0.58 | 0.38 | 0.50 | 1.02 | 0.55 | 1.04 |
| 40% of Water Depth | 0.43 | 0.58 | 1.00 | 0.56 | 0.37 | 0.48 | 0.98 | 0.53 | 1.00 |
| 30% of Water Depth | 0.41 | 0.56 | 0.96 | 0.54 | 0.35 | 0.47 | 0.94 | 0.51 | 0.96 |
| 20% of Water Depth | 0.39 | 0.53 | 0.91 | 0.51 | 0.33 | 0.44 | 0.89 | 0.48 | 0.91 |
| 10% of Water Depth | 0.35 | 0.48 | 0.82 | 0.46 | 0.30 | 0.40 | 0.80 | 0.43 | 0.82 |
| 5% of Water Depth | 0.32 | 0.43 | 0.74 | 0.42 | 0.27 | 0.36 | 0.73 | 0.39 | 0.74 |
| 1m asb | 0.31 | 0.42 | 0.72 | 0.40 | 0.26 | 0.35 | 0.70 | 0.38 | 0.72 |
| | | | | | | | | | |

**Table 7-14. Extreme Currents Characteristics – Hamilton Platform – Directional Data**

### 7.5.3 Hamilton North Field

| Height/Depth Ratio | North | Northeast | East | Southeast | South | Southwest | West | Northwest | Omni |
|---|---|---|---|---|---|---|---|---|---|
| 1 Year | | | | | | | | | |
| Surface | 0.42 | 0.61 | 0.83 | 0.50 | 0.36 | 0.48 | 0.78 | 0.47 | 0.83 |
| 75% of Water Depth | 0.42 | 0.61 | 0.83 | 0.50 | 0.36 | 0.48 | 0.78 | 0.47 | 0.83 |
| 50% of Water Depth | 0.42 | 0.61 | 0.83 | 0.50 | 0.36 | 0.48 | 0.78 | 0.47 | 0.83 |
| 40% of Water Depth | 0.40 | 0.59 | 0.80 | 0.48 | 0.35 | 0.46 | 0.76 | 0.46 | 0.80 |
| 30% of Water Depth | 0.38 | 0.57 | 0.77 | 0.46 | 0.33 | 0.45 | 0.73 | 0.44 | 0.77 |
| 20% of Water Depth | 0.36 | 0.54 | 0.73 | 0.44 | 0.31 | 0.42 | 0.68 | 0.41 | 0.73 |
| 10% of Water Depth | 0.33 | 0.49 | 0.66 | 0.40 | 0.28 | 0.38 | 0.62 | 0.37 | 0.66 |
| 5% of Water Depth | 0.30 | 0.44 | 0.60 | 0.36 | 0.26 | 0.35 | 0.56 | 0.34 | 0.60 |
| 1m asb | 0.29 | 0.43 | 0.59 | 0.35 | 0.25 | 0.34 | 0.55 | 0.33 | 0.59 |
| | | | | | | | | | |
| 10 Years | | | | | | | | | |
| Surface | 0.45 | 0.66 | 0.90 | 0.54 | 0.39 | 0.52 | 0.85 | 0.51 | 0.90 |
| 75% of Water Depth | 0.45 | 0.66 | 0.90 | 0.54 | 0.39 | 0.52 | 0.85 | 0.51 | 0.90 |
| 50% of Water Depth | 0.45 | 0.66 | 0.90 | 0.54 | 0.39 | 0.52 | 0.85 | 0.51 | 0.90 |
| 40% of Water Depth | 0.43 | 0.64 | 0.87 | 0.52 | 0.37 | 0.50 | 0.82 | 0.49 | 0.87 |
| 30% of Water Depth | 0.42 | 0.61 | 0.83 | 0.50 | 0.36 | 0.48 | 0.78 | 0.47 | 0.83 |
| 20% of Water Depth | 0.39 | 0.58 | 0.78 | 0.47 | 0.34 | 0.45 | 0.74 | 0.45 | 0.78 |
| 10% of Water Depth | 0.35 | 0.52 | 0.71 | 0.43 | 0.31 | 0.41 | 0.67 | 0.40 | 0.71 |
| 5% of Water Depth | 0.32 | 0.47 | 0.64 | 0.39 | 0.28 | 0.37 | 0.61 | 0.37 | 0.64 |
| 1m asb | 0.32 | 0.47 | 0.63 | 0.38 | 0.27 | 0.37 | 0.60 | 0.36 | 0.63 |
| | | | | | | | | | |
| 50 Years | | | | | | | | | |
| Surface | 0.47 | 0.70 | 0.94 | 0.57 | 0.41 | 0.55 | 0.89 | 0.54 | 0.94 |
| 75% of Water Depth | 0.47 | 0.70 | 0.94 | 0.57 | 0.41 | 0.55 | 0.89 | 0.54 | 0.94 |
| 50% of Water Depth | 0.47 | 0.70 | 0.94 | 0.57 | 0.41 | 0.55 | 0.89 | 0.54 | 0.94 |
| 40% of Water Depth | 0.46 | 0.67 | 0.91 | 0.55 | 0.39 | 0.53 | 0.86 | 0.52 | 0.91 |
| 30% of Water Depth | 0.44 | 0.65 | 0.87 | 0.53 | 0.38 | 0.51 | 0.82 | 0.50 | 0.87 |
| 20% of Water Depth | 0.41 | 0.61 | 0.83 | 0.50 | 0.36 | 0.48 | 0.78 | 0.47 | 0.83 |
| 10% of Water Depth | 0.37 | 0.55 | 0.75 | 0.45 | 0.32 | 0.43 | 0.70 | 0.42 | 0.75 |
| 5% of Water Depth | 0.34 | 0.50 | 0.68 | 0.41 | 0.29 | 0.39 | 0.64 | 0.38 | 0.68 |
| 1m asb | 0.33 | 0.49 | 0.67 | 0.40 | 0.29 | 0.39 | 0.63 | 0.38 | 0.67 |
| | | | | | | | | | |
| 100 Years | | | | | | | | | |
| Surface | 0.48 | 0.71 | 0.96 | 0.58 | 0.42 | 0.56 | 0.91 | 0.55 | 0.96 |
| 75% of Water Depth | 0.48 | 0.71 | 0.96 | 0.58 | 0.42 | 0.56 | 0.91 | 0.55 | 0.96 |
| 50% of Water Depth | 0.48 | 0.71 | 0.96 | 0.58 | 0.42 | 0.56 | 0.91 | 0.55 | 0.96 |
| 40% of Water Depth | 0.46 | 0.69 | 0.93 | 0.56 | 0.40 | 0.54 | 0.88 | 0.53 | 0.93 |
| 30% of Water Depth | 0.45 | 0.66 | 0.89 | 0.54 | 0.39 | 0.52 | 0.84 | 0.51 | 0.89 |
| 20% of Water Depth | 0.42 | 0.62 | 0.84 | 0.51 | 0.36 | 0.49 | 0.79 | 0.48 | 0.84 |
| 10% of Water Depth | 0.38 | 0.56 | 0.76 | 0.46 | 0.33 | 0.44 | 0.72 | 0.43 | 0.76 |
| 5% of Water Depth | 0.35 | 0.51 | 0.69 | 0.42 | 0.30 | 0.40 | 0.65 | 0.39 | 0.69 |
| 1m asb | 0.34 | 0.50 | 0.68 | 0.41 | 0.29 | 0.39 | 0.64 | 0.39 | 0.68 |

**Table 7-15. Extreme Currents Characteristics – Hamilton North Platform – Directional Data**

### 7.5.4 Lennox Field

| Height (asb) | N | NE | E | SE | S | SW | W | NW | Omni |
|---|---|---|---|---|---|---|---|---|---|
| **1 Year** | m/s | m/s | m/s | m/s | m/s | m/s | m/s | m/s | m/s |
| Surface (12m asb) | 0.41 | 0.55 | 0.70 | 0.39 | 0.28 | 0.41 | 0.70 | 0.40 | 0.70 |
| 9m asb | 0.41 | 0.55 | 0.70 | 0.39 | 0.28 | 0.41 | 0.70 | 0.40 | 0.70 |
| 6m asb | 0.41 | 0.55 | 0.70 | 0.39 | 0.28 | 0.41 | 0.70 | 0.40 | 0.70 |
| 5m asb | 0.40 | 0.53 | 0.69 | 0.38 | 0.27 | 0.40 | 0.69 | 0.39 | 0.69 |
| 4m asb | 0.40 | 0.52 | 0.67 | 0.36 | 0.26 | 0.39 | 0.67 | 0.37 | 0.67 |
| 2m asb | 0.35 | 0.47 | 0.60 | 0.33 | 0.24 | 0.35 | 0.60 | 0.33 | 0.60 |
| 1m asb | 0.32 | 0.42 | 0.55 | 0.30 | 0.22 | 0.32 | 0.55 | 0.31 | 0.55 |
| **10 Years** | m/s | m/s | m/s | m/s | m/s | m/s | m/s | m/s | m/s |
| Surface (12m asb) | 0.45 | 0.59 | 0.76 | 0.42 | 0.30 | 0.45 | 0.76 | 0.43 | 0.76 |
| 9m asb | 0.45 | 0.59 | 0.76 | 0.42 | 0.30 | 0.45 | 0.76 | 0.43 | 0.76 |
| 6m asb | 0.45 | 0.59 | 0.76 | 0.42 | 0.30 | 0.45 | 0.76 | 0.43 | 0.76 |
| 5m asb | 0.44 | 0.57 | 0.74 | 0.41 | 0.29 | 0.43 | 0.74 | 0.42 | 0.74 |
| 4m asb | 0.43 | 0.56 | 0.72 | 0.39 | 0.29 | 0.42 | 0.72 | 0.40 | 0.72 |
| 2m asb | 0.38 | 0.50 | 0.65 | 0.35 | 0.26 | 0.38 | 0.65 | 0.36 | 0.65 |
| 1m asb | 0.34 | 0.46 | 0.59 | 0.32 | 0.24 | 0.34 | 0.59 | 0.33 | 0.59 |
| **50 Years** | m/s | m/s | m/s | m/s | m/s | m/s | m/s | m/s | m/s |
| Surface (12m asb) | 0.47 | 0.62 | 0.80 | 0.44 | 0.32 | 0.47 | 0.80 | 0.45 | 0.80 |
| 9m asb | 0.47 | 0.62 | 0.80 | 0.44 | 0.32 | 0.47 | 0.80 | 0.45 | 0.80 |
| 6m asb | 0.47 | 0.62 | 0.80 | 0.44 | 0.32 | 0.47 | 0.80 | 0.45 | 0.80 |
| 5m asb | 0.46 | 0.60 | 0.78 | 0.43 | 0.31 | 0.45 | 0.78 | 0.44 | 0.78 |
| 4m asb | 0.45 | 0.59 | 0.76 | 0.41 | 0.30 | 0.44 | 0.76 | 0.42 | 0.76 |
| 2m asb | 0.40 | 0.53 | 0.68 | 0.37 | 0.27 | 0.40 | 0.68 | 0.38 | 0.68 |
| 1m asb | 0.36 | 0.48 | 0.62 | 0.34 | 0.25 | 0.36 | 0.62 | 0.35 | 0.62 |
| **100 Years** | m/s | m/s | m/s | m/s | m/s | m/s | m/s | m/s | m/s |
| Surface (12m asb) | 0.48 | 0.63 | 0.82 | 0.45 | 0.33 | 0.48 | 0.82 | 0.46 | 0.82 |
| 9m asb | 0.48 | 0.63 | 0.82 | 0.45 | 0.33 | 0.48 | 0.82 | 0.46 | 0.82 |
| 6m asb | 0.48 | 0.63 | 0.82 | 0.45 | 0.33 | 0.48 | 0.82 | 0.46 | 0.82 |
| 5m asb | 0.47 | 0.61 | 0.80 | 0.44 | 0.32 | 0.46 | 0.80 | 0.45 | 0.80 |
| 4m asb | 0.46 | 0.60 | 0.78 | 0.42 | 0.31 | 0.45 | 0.78 | 0.43 | 0.78 |
| 2m asb | 0.41 | 0.54 | 0.69 | 0.38 | 0.28 | 0.41 | 0.69 | 0.39 | 0.69 |
| 1m asb | 0.37 | 0.49 | 0.63 | 0.35 | 0.26 | 0.37 | 0.63 | 0.36 | 0.63 |

**Table 7-16. Extreme Currents Characteristics – Lennox Platform – Directional Data**

## 8.0 TYPICAL CROSSING METHODOLOGY

The new pipeline offshore crossing of the LBA CCS project can be achieved using various methods but this section will focus on three methodologies. The methodology to be used in pipeline crossings in this project has to align with the pipeline and cable protection philosophy [Ref.6]

The 3 typical methodologies are:

- Crossing with Concrete mattresses
- Crossing with Rock berm
- Concrete Sleeper

As per the LBA CCS Pipeline design requirements [Ref.3], the minimum vertical separation between crossing shall be 500mm.

### 8.1 Crossing with Mattress

For this method the crossing is attained by aligning one or more mattresses at each side of the existing line/cable in order to reach the required vertical distance between the pipeline /cables being crossed over.

To transition smoothly over the crossing, two or more mattresses are installed parallel to the crossing line/cable. This is to ensure a smooth profile over the crossing maximum height until the line/cable touches down on the seabed.

The following concrete mattresses dimensions can be used for this project.

| Parameters | Dimensions |
|---|---|
| Width | 3 m |
| Length | 6.0 m |
| Height | 0.3 m |

**Table 8-1 Typical Mattress Dimensions**

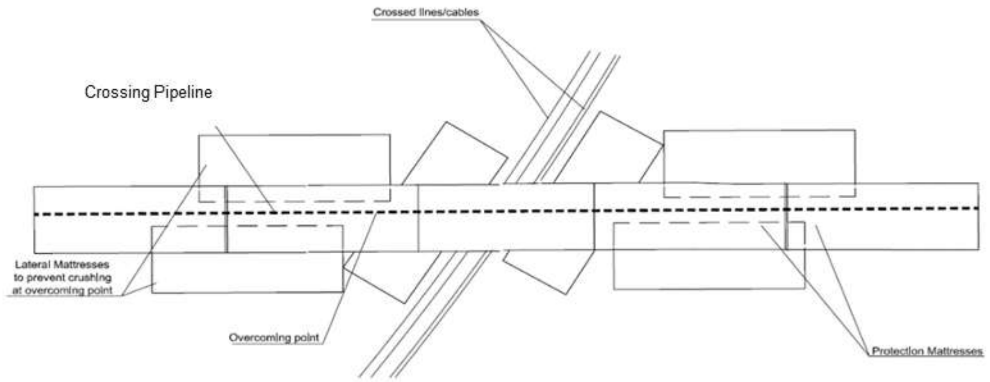


**Figure 8-1 – Typical Mattress Crossing for both Scenarios**

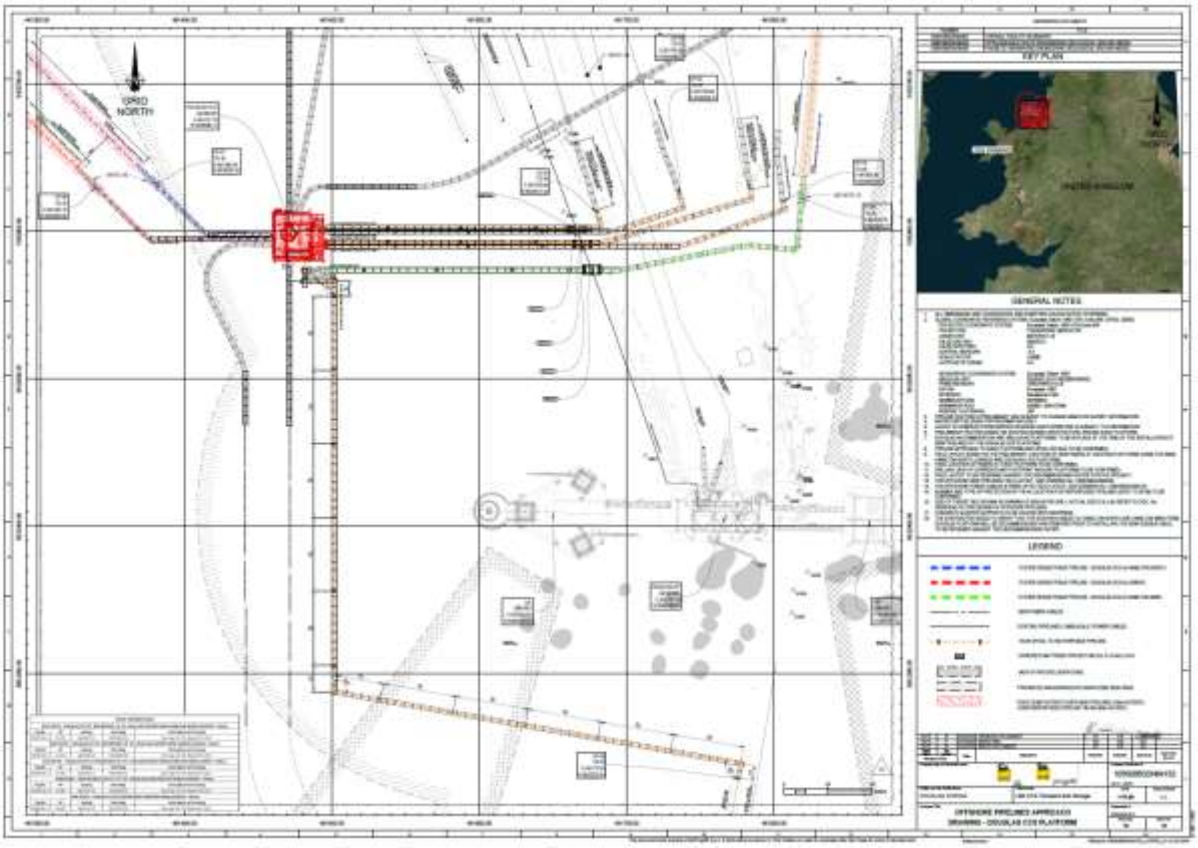

**Figure 8-2 – Proposed Mattress for Spool Protection at Douglas CCS Approach**

### 8.2 Crossing with Rock Berm

This crossing is attained by rock dumping over the third-party pipeline or any existing pipeline to be crossed thereby protecting the pipeline and creating the required 500mm vertical distance between the pipeline /cables being crossed over.

The following data are typically included in the rock dumping work scope:

- Rock size
- Rock cover
- Rock width
- Rock berm side slopes
- Dumping accuracy
- Dumping restrictions
- Other dumping requirements
- Pipeline characteristics

For the selection of rock sizes, details can be found in COMPANY Standard [Ref.26]. The rock characteristics, and the proposed rock dumping method, shall ensure that the required intervention work is completed within the work scope specifications.

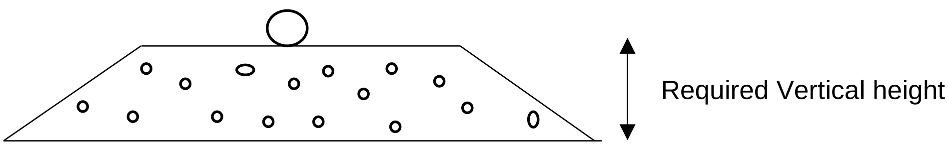


**Figure 8-3 – Typical Rock dump crossing schematics**

### 8.3 Crossing with Concrete Sleeper

Concrete sleepers are used to support pipelines at crossing locations. They are used to obtain a firm grip to withstand high-velocity underwater current which ensures the base of the sleepers is firmly embedded on the seabed. Sleepers are neoprene or commercial rubber coated for pipeline protection. It is assumed a typical concrete sleeper has a dimension of 6m (length) x 2m (height).

For LBA CCS project, concrete sleepers are proposed for crossing existing pipeline and power cables at Douglas CCS platform approach and other crossing locations.

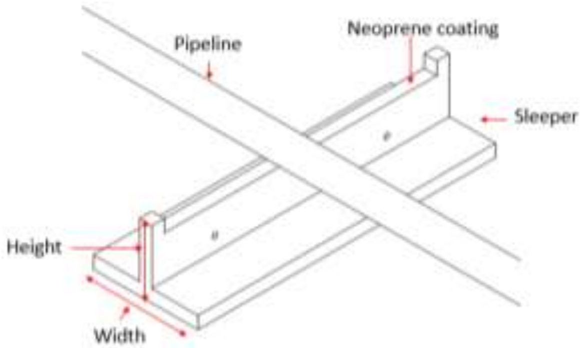


**Figure 8-4 – Typical Concrete Sleeper at Pipeline Crossing**

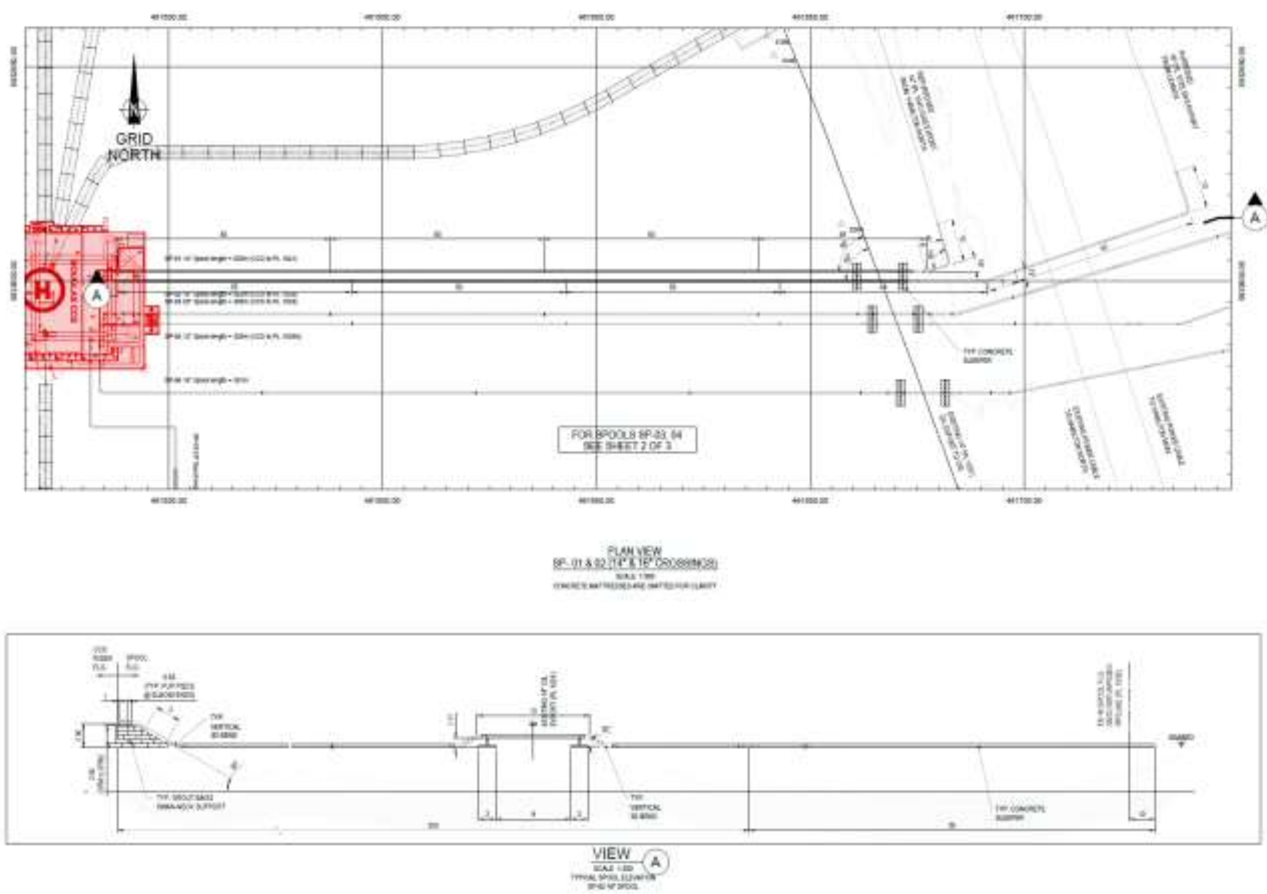


**Figure 8-5 – Proposed Concrete Sleeper at Pipeline and Cable Crossing (At Douglas CCS Platform) for Spools 14in PL1041 & 16in PL1035**

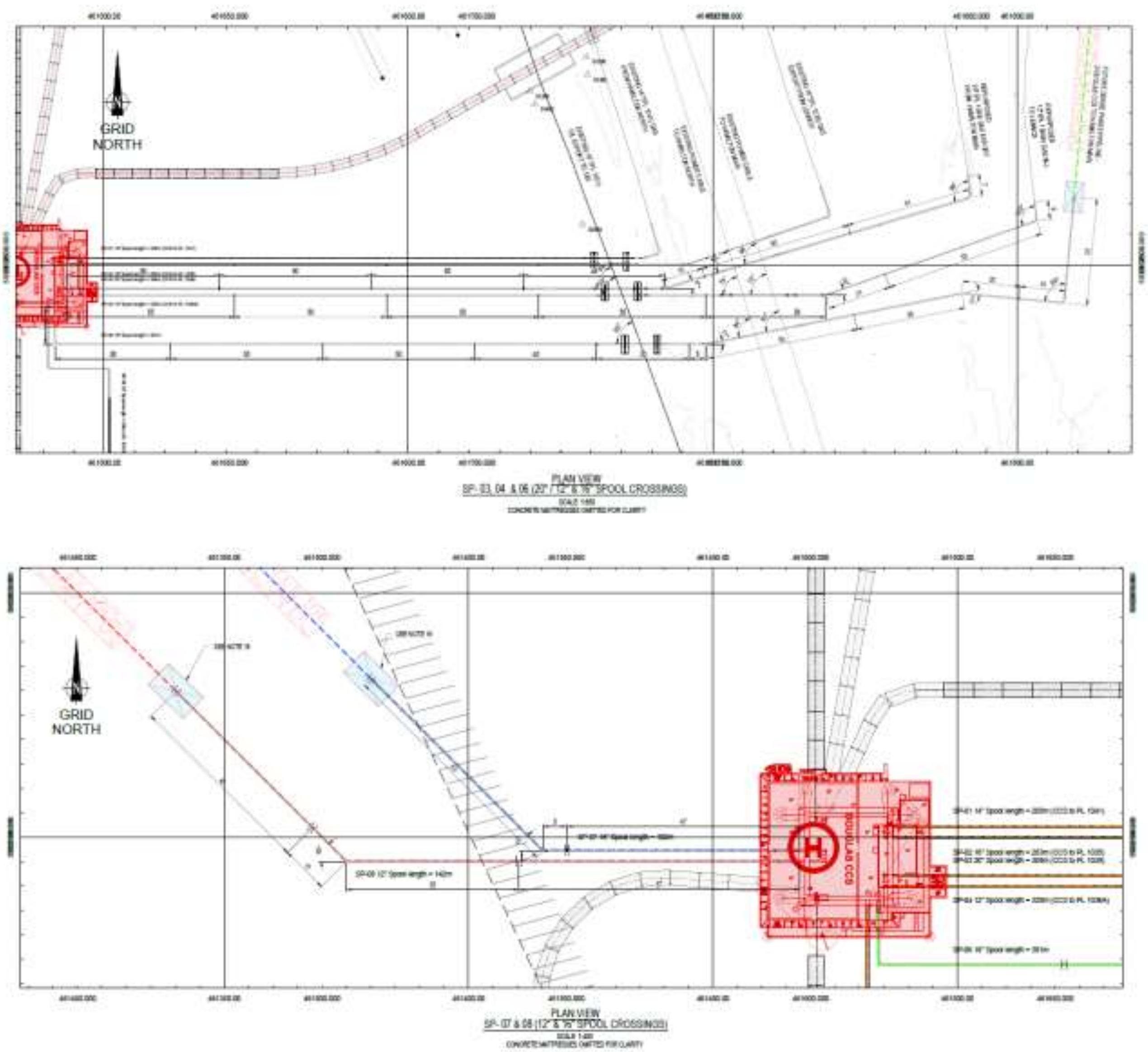


**Figure 8-6 – Proposed Concrete Sleeper at Pipeline and Cable Crossing (At Douglas CCS Platform) for Spools 20in PL1039, 12in PL1036a, 16in Future to Hamilton Main, 16in Future to Lennox & 12in Future to Hamilton North**

Table 8-2 below proposes the number of sleepers with height required for the new future pipelines crossing location.

| LBA CCS Pipelines | Pipeline/Cable to be Crossed | Proposed Number of Sleepers | Proposed Sleepers Height (m) |
|---|---|---|---|
| New 16in Future Pipeline from new Douglas CCS Platform to Lennox Platform | New Power Cable to Hamilton North | 2 | 1 |
| | Existing Power Cable to Hamilton North | 2 | |
| | Existing 14-inch Gas Export Pipeline PL1041 + 2-inch methanol PL1042 piggyback from Hamilton North to Douglas | 2 | |
| | Existing 8-inch Production PL2939 from Douglas to Conway Platform | 2 | |
| | 3-inch Condensate PL2941 Piggyback from Douglas to Conway Platform | 2 | |
| | Existing 8-inch Water Injection PL2940 Pipeline from Douglas to Conway Platform | 2 | |
| | Existing 14-inch Oil Export PL1031 Pipeline from Douglas to Offshore Loading Unit | 2 | |
| New 12in Future Pipeline from Douglas CCS Platform to Hamilton North | Existing 8-inch Production PL2939 from Douglas to Conway Platform | 2 | |
| | 3-inch Condensate PL2941 Piggyback from Douglas to Conway Platform | 2 | |
| | Existing 8-inch Water Injection PL2940 from Douglas to Conway Platform | 2 | |
| | Existing 14-inch Oil Export Pipeline PL1031 from Douglas to Offshore Loading Unit | 2 | |
| Total number of proposed sleepers for the new future pipelines crossings | | **22** | |

**Table 8-2 Proposed Sleepers with Height for New Future Pipeline Crossings**

Table 8-3 below proposes the number of sleepers with height required for the new spools crossing at Douglas CCS approach.

| LBA CCS Spools | Pipeline/Cable to be Crossed | Proposed Number of Sleepers | Proposed Sleepers Height (m) |
|---|---|---|---|
| 14” Spool (PL1041) – Douglas CCS to Hamilton North | Existing 14” (PL1031) Oil Export to OSI | 2 | 1.1 |
| 16” Spool (PL1035) – Douglas CCS to Lennox | Existing 14” (PL1031) Oil Export to OSI | - | |
| 20” Spool (PL1039) – Douglas CCS to Hamilton Main | Existing Power Cable to Hamilton North<br>Existing 14” (PL1031) Oil Export to OSI | 2 | |
| 12” Spool (PL1036A) – Douglas CCS to Lennox | Existing 14” (PL1031) Oil Export to OSI | - | |
| 16” Spool – New Future Douglas CCS to Hamilton Main | Existing 14” (PL1031) Oil Export to OSI | 2 | |
| Total number of proposed sleepers for the new spool crossings at Douglas CCS Platform approach | | **6** | |

**Table 8-3 Proposed Sleepers with Height for New Spool Crossings at Douglas CCS Approach**

## 9.0 ALLOWABLE FREE SPAN ASSESMENT

For the LBA CCS project, concrete sleepers will be used to cross existing PL1031 and two power cables at the Douglas CCS platform approach for new spools. Details of the new spools crossing are presented in Table 4-5. Concrete sleepers will also be used for the new future pipelines crossing and details of these crossing are presented in Table 4-4. As a result, the proposed solution will create spans at crossing locations as mentioned in Figure 8-5. Therefore, allowable free span analysis will be performed in accordance with DNV-RP-F105 [Ref.28].

The analysis involves the derivation of the maximum allowable span length to avoid fatigue damage due Vortex Induced Vibration while satisfying the ULS check performed by the software. The following load effects shall be considered for ULS check.

- Static bending and cross-flow VIV in the vertical direction
- In-line VIV, drag and inertia loads due to wave and current

For the allowable free span screening assessment, pinned-pinned boundary condition has been selected and value are given in Table 9-1 [Ref.28]. Fatigue analysis shall be performed if required using DNV software “FATFREE” or equivalent software to establish the allowable spans.

| Boundary Condition | Pinned-Pinned | Fixed-Fixed | RP-F105 Single Span |
|---|---|---|---|
| $C_1$ | 1.57 | 3.56 | 3.56 |
| $C_2$ | 1.00 | 0.25 | 0.25 |
| $C_3$ | 0.80 | 0.20 | 0.40 |
| $C_5$ | 1/8 | 1/12 | 1/12 |
| $C_6$ | 5/384 | 1/384 | 1/384 |

**Table 9-1 Boundary Condition Coefficients**

### 9.1 Allowable Free Span – Existing Pipelines

Allowable free span length for existing pipelines has been calculated previously [Ref.19] and results are presented in Table 9-2.

| Pipeline | Mode | Max Allowable Span Length (m) | |
|---|---|---|---|
| | | Static | Dynamic |
| PL1030 | Installation | 81.9 | 32.8 |
| | Hydrotest | 50.5 | 32.3 |
| | Operational | 42.9 | 26.8 |
| PL1034 | Installation | - | 16.9 |
| | Hydrotest | - | 16.5 |
| | Operational | - | 14.6 |
| PL1035 | Installation | 49.6 | 18.6 |
| | Hydrotest | 32.9 | 18.0 |
| | Operational | 29.8 | 16.3 |
| PL1036A | Installation | - | 15.7 |
| | Hydrotest | - | 15.2 |
| | Operational | - | 13.7 |
| PL1039 | Installation | 70.9 | 29.7 |
| | Hydrotest | 43.8 | 29.1 |
| | Operational | 41.0 | 24.5 |
| PL1041 | Installation | 57.0 | 21.9 |
| | Hydrotest | 38.8 | 21.4 |
| | Operational | 29.2 | 16.8 |

**Table 9-2 Summary of Maximum Allowable Span Lengths – Existing Pipelines**

## 9.2 Allowable Free Span – New Future Pipelines

Allowable free span analysis has been performed using DNV PET for the new future pipelines and results are presented in Table 9-3.

| Pipeline | Mode | Max Allowable Span Length (m) | | |
|---|---|---|---|---|
| | | Static | In-Line | Cross-Flow |
| 16in New Future Pipeline - Douglas CCS to Lennox | Installation | 59.2 | 10.84 | 23.6 |
| | Hydrotest | 49.69 | 10.37 | 22.73 |
| | Operational | 12.58 | 9.42 | 12.58 |
| 12in New Future Pipeline – Douglas CCS to Hamilton North | Installation | 49.42 | 8.62 | 17.36 |
| | Hydrotest | 39.86 | 8.28 | 16.71 |
| | Operational | 12.11 | 7.51 | 12.11 |
| 16in New Future Pipeline - Douglas CCS to Hamilton Main Note 1 | Installation | 59.2 | 10.84 | 23.6 |
| | Hydrotest | 49.69 | 10.37 | 22.73 |
| | Operational | 12.58 | 9.42 | 12.58 |

Notes:
1 – Mechanical, environmental and sea state data are the same as used for 16in new future pipeline (Douglas CCS – Lennox) free span analysis. Therefore, no analysis has been performed.

**Table 9-3 Summary of Maximum Allowable Span Lengths – New Future Pipelines**

## 10.0 PIPELINE LIFT-OFF FROM SLEEPERS

The results of the sleeper lift off assessment for the spools at Douglas CCS are presented in Table 10-1. The analysis was carried out in Autopipe software for operation and hydrotest load cases, where the lift-off is taken from the node at the sleeper location.

| Spool ID | Location | Condition | Phase | Node | Liftoff |
|---|---|---|---|---|---|
| [-] | [-] | [-] | [-] | [-] | [mm] |
| PL1041 | Douglas CCS | Operation | Gas | Near Sleeper | 0.00 |
| | | | | Far Sleeper | 0.00 |
| | | Hydrotest | Gas | Near Sleeper | 0.00 |
| | | | | Far Sleeper | 0.00 |
| PL1035 | Douglas CCS | Operation | Gas | Near Sleeper | 1.27 |
| | | | | Far Sleeper | 0.00 |
| | | Hydrotest | Gas | Near Sleeper | 0.00 |
| | | | | Far Sleeper | 0.00 |
| PL1039 | Douglas CCS | Operation | Gas | Near Sleeper | 4.21 |
| | | | | Far Sleeper | 0.94 |
| | | Hydrotest | Gas | Near Sleeper | 0.25 |
| | | | | Far Sleeper | 0.00 |
| PL1036A | Douglas CCS | Operation | Gas | Near Sleeper | 11.71 |
| | | | | Far Sleeper | 18.68 |
| | | Hydrotest | Gas | Near Sleeper | 13.14 |
| | | | | Far Sleeper | 13.01 |
| | | Operation | Dense | Near Sleeper | 30.83 |
| | | | | Far Sleeper | 23.17 |
| | | Hydrotest | Dense | Near Sleeper | 6.54 |
| | | | | Far Sleeper | 9.31 |

**Table 10-1 – Sleeper Lift at Douglas CCS Results Summary [Ref.22]**

# 11.0 CONCRETE MATTRESS DESIGN REQUIREMENTS

## 11.1 Mattress Specification

The typical mattress specification for the crossing design of the pipeline for LBA CCS project is presented below:

| Length | Width | Thickness | Density | Density Edge Block | Typ. Weight in Air | Typ. Weight in Water |
|---|---|---|---|---|---|---|
| [mm] | [mm] | [mm] | [kg/m$^3$] | [kg/m$^3$] | [Tonnes] | [Tonnes] |
| 6000 | 3000 | 300 | 2400 | 3600 | 10.08 | 6.62 |

**Table 11-1 Recommended Mattress Specification**

## 11.2 Design Features

The mattresses shall be designed to bend in two planes, by means of concrete blocks or units of suitable dimensions (length, breadth and height) and weight which are held together by ropes, to achieve the functionality requirements including but not limited to, structural strength, stability, flexibility, weight, etc.

Each mattress shall have adequate flexibility to conform to the profile of the seabed and/or pipeline onto which it is to be laid. The mattresses shall form a continuous profile giving an approximate semi-circular cross section shape with sufficient run out length on either side of the pipeline resting on the seabed. The flexibility of the mattresses shall be retained throughout the design life.

The mattresses shall be designed against abrasion by provision of neoprene coating of minimum thickness 3mm or approved equivalent. The mattresses shall be designed to retain their functionality and structural integrity for recovery at any time during the design life.

Each mattress shall incorporate permanent handling aids to permit easy installation and removal by a single crane with diver/ROV assistance. The permanent handling aids on each mattress shall be designed to withstand all anticipated loadings during all phases of the installation operations, including but not limited to, handling, transportation, lifting, installation, etc. Dynamic effects shall be considered in the design of permanent handling aids. Installation devices and handling aids shall not create snagging hazards for divers.

The density of the mattress shall be optimised within the overall size as specified in COMPANY approved Project Drawings. The mattress edge lift resistance shall be enhanced with a "Nose and Notch" or equivalent design subject to the approval of COMPANY.

## 11.3 Design Requirements for Stabilisation

The mattress shall be designed to ensure its stability. Mattress shall not be dislodged or displaced from its as-installed position when subject to environmental loadings anytime during the design life and, as a minimum, shall be designed for the two failure scenarios as follows:

### 11.3.1 Stability Against Leading Edge Lift

Mattress shall not be lifted at the edge and rolled off the pipeline when subject to environmental loadings anytime during the design life.

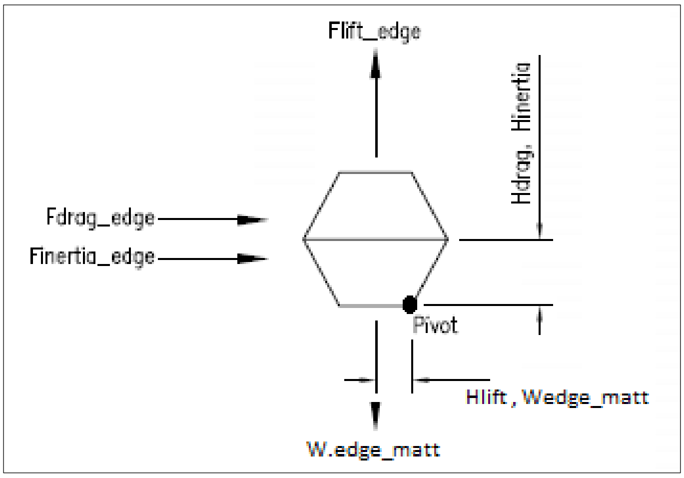


**Figure 11-1 Hexagonal Block Forces Diagram**

Moments at the pivot point must be satisfied for stability against edge lift and is expressed by:

$$(F_{drag\_edge} \cdot h_{drag} + F_{inertia\_edge} \cdot h_{inertia}) \leq (W_{SE} - F_{lift\_edge}) \cdot h_{lift}$$

Where,

| | | |
|---|---|---|
| $W_{SE}$ | : | Submerged weight of the edge blocks per unit length along the mattress edge |
| $F_{drag\_edge}$ | : | Drag force acting on the block edge |
| $F_{inertia\_edge}$ | : | Inertia force acting on the block edge |
| $F_{lift\_edge}$ | : | Lift force acting on the block edge |
| $h_{drag}$ | : | Reference height for drag |
| $h_{inertia}$ | : | Reference height for inertia |
| $h_{lift}$ | : | Reference height for lift |

### 11.3.2 Stability Against Sliding

The requirement to the mattress stability against sliding is expressed by:

$$F_H \leq \frac{\mu_m}{f_s}(W_{sm} - F_L)$$

Where,

| | | |
|---|---|---|
| $F_H$ | : | Horizontal force |
| $\mu_m$ | : | Mattress to soil friction coefficient |
| $f_s$ | : | Safety factor (min. of 1.1) |
| $W_{sm}$ | : | Submerged weight of mattress per unit length |
| $F_L$ | : | Lift force |

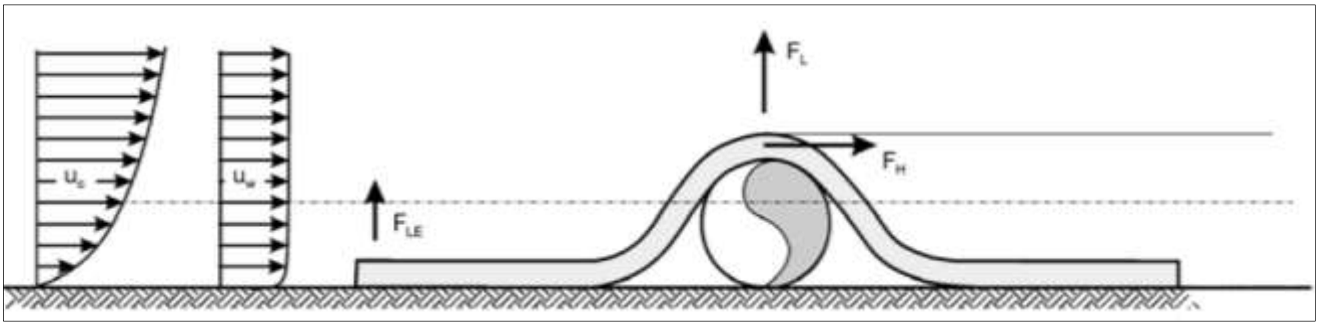


**Figure 11-2 Mattress on Pipeline - Definition of Parameters**

### 11.4 Mattress Orientation / Placement

The mattress can be laid in two orientations as show in Figure 11-3. The length of the mattress depends upon the orientation in which it is laid, and the mattress length is always parallel to the pipeline. The final orientation shall be based on the mattress stability assessments and shall be confirmed during detailed design engineering by the CONTRACTOR using accurate metocean data for water depths.

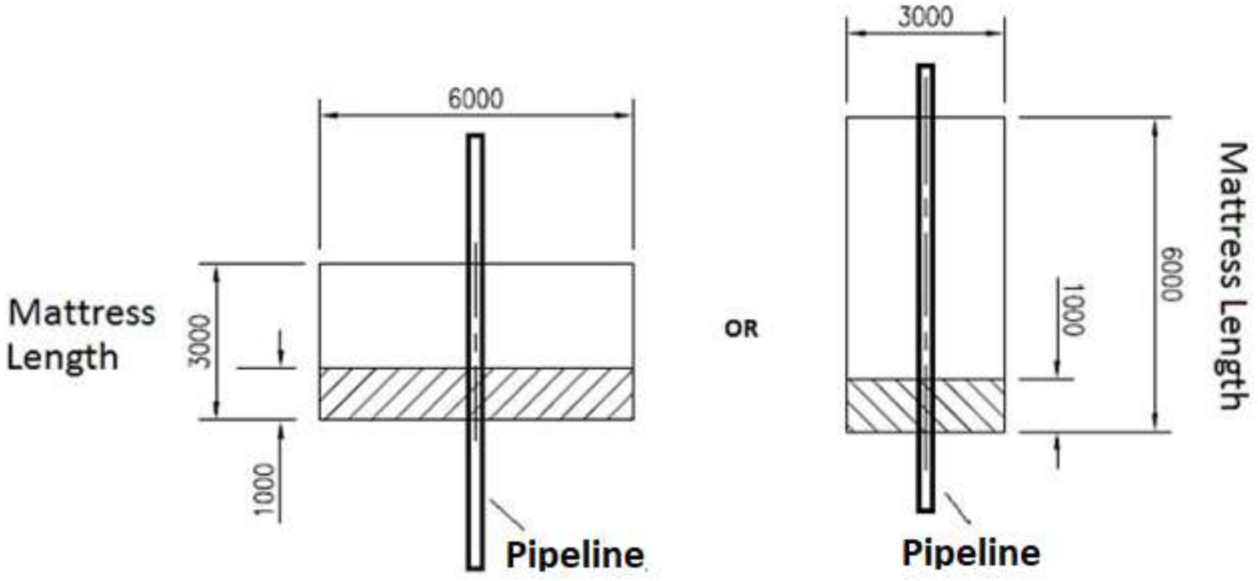


**Figure 11-3 Mattress Orientation**

After placement of mattress over the pipeline, the mattress shall maintain the pipeline in its initial as-laid position. The pipeline shall not be displaced from underneath the mattress such that it is no longer be covered by the mattress when subject to environmental loadings anytime during the design life.

All loadings due to environmental conditions, including but not limited to, wave, current, soil subsidence etc. shall be accounted for in the stability design. The environmental loadings for design shall be, as a minimum, 100-year return period for operation condition. The environmental loadings shall be based on relevant metocean data and taken in the direction resulting in the worst loading combination on the mattresses. Soil properties and geotechnical data for design of mattress shall be based on relevant soil investigation data.

### 11.5 Design Requirements for Protection

Typically, concrete mattress shall be able to provide protection from dropped objects and trawl boards. Flexible concrete mattresses shall be capable of absorbing 60 kJ impact load and be stable under the relevant design environmental loads. Resistance to trawl boards can be achieved through the design of the mattress edges for example butt or tapered edge.

# 12.0 ROCK DUMPING DESIGN REQUIREMENTS

## 12.1 Rock Berm Requirements

The main purpose of the rock berm is to prevent damage caused by trawling and anchoring. To safeguard this protection, the rock berm also needs to be sufficiently stable to withstand hydrodynamic loads generated by currents and waves.

The method of rock installation should be suitable for the product to be deployed with the required profile and accuracy in the water depth at site. The rock dumping procedure shall assure that the stability of any subsea slope is not endangered.

All rock dumping requirements shall be in accordance as well as the provisions within [Ref.26] and [Ref.27]. This shall be confirmed by the CONTRACTOR as part of the detailed design.

## 13.0 CROSSING PROTECTION REQUIREMENT

The pipelines and spools shall be fully protected along their whole length. The pipelines shall be trenched and backfilled along their length and spools shall be mattress protected. At crossing location, it is necessary to protect against the potential hazards associated with dropped objects, shipping lanes and fishing activities that the pipeline/spool could be exposed to.

Damage to subsea pipeline and spool from the above activities can be minimised by limiting the risks, if possible, or by preventing damage during the service life of the system with an appropriate protection philosophy. Most of the existing subsea architecture in waters off the Coast of the UK, including the Irish and North Seas, possesses a similar protection philosophy. Consequently, the protection measures adopted for the Liverpool Bay CCS pipelines are consistent with general industry practice and are not based on the results of a field specific design study.

### 13.1 Dropped Object

The philosophy adopted, to mitigate the risk presented by dropped objects, is to minimise handling of objects over the pipelines/spools and, where necessary, provide protection and adopt strict handling procedures. Detailed protection philosophy is presented in [Ref.6].

### 13.2 Fishing Gear Interaction

The Irish Sea is an area of intense fishing activity, and that demersal fishing, i.e., otter trawls and trawl beams, is the predominant method used in these waters. The otter trawl consists of a wide net, held open by a pair of otter boards or doors, and towed along the seabed. The demersal fishing gears and its features which could potentially interfere with pipelines and tie-in spools on the seabed.

Based on the intensity of fishing in the study area as shown in Figure 13-1 and possible impact on the pipeline and spools, the probability of occurrence is high, and the LBA CCS pipeline left unprotected, will unlikely be able to survive the loads generated during fishing interaction incidents, hence the pipeline and tie-spool needs to be protected. The following mitigation are proposed:

- Trenching and backfilling the pipeline along its route will provide the protection needed, the section of the pipeline such as spools which cannot be lowered below the seabed shall be protected with mattress or rock dump
- An exclusion zone of 500m radius can also be used to protect the pipeline and tie-in spool if possible and this will protect the pipeline from fishing gear interactions and hence no protection will be needed specifically for fishing interaction.
- Alert the fishing Industry to the presence of the pipeline system, via liaison with relevant bodies such as the Sea fish Industry Authority (SFIA) and FishSAFE

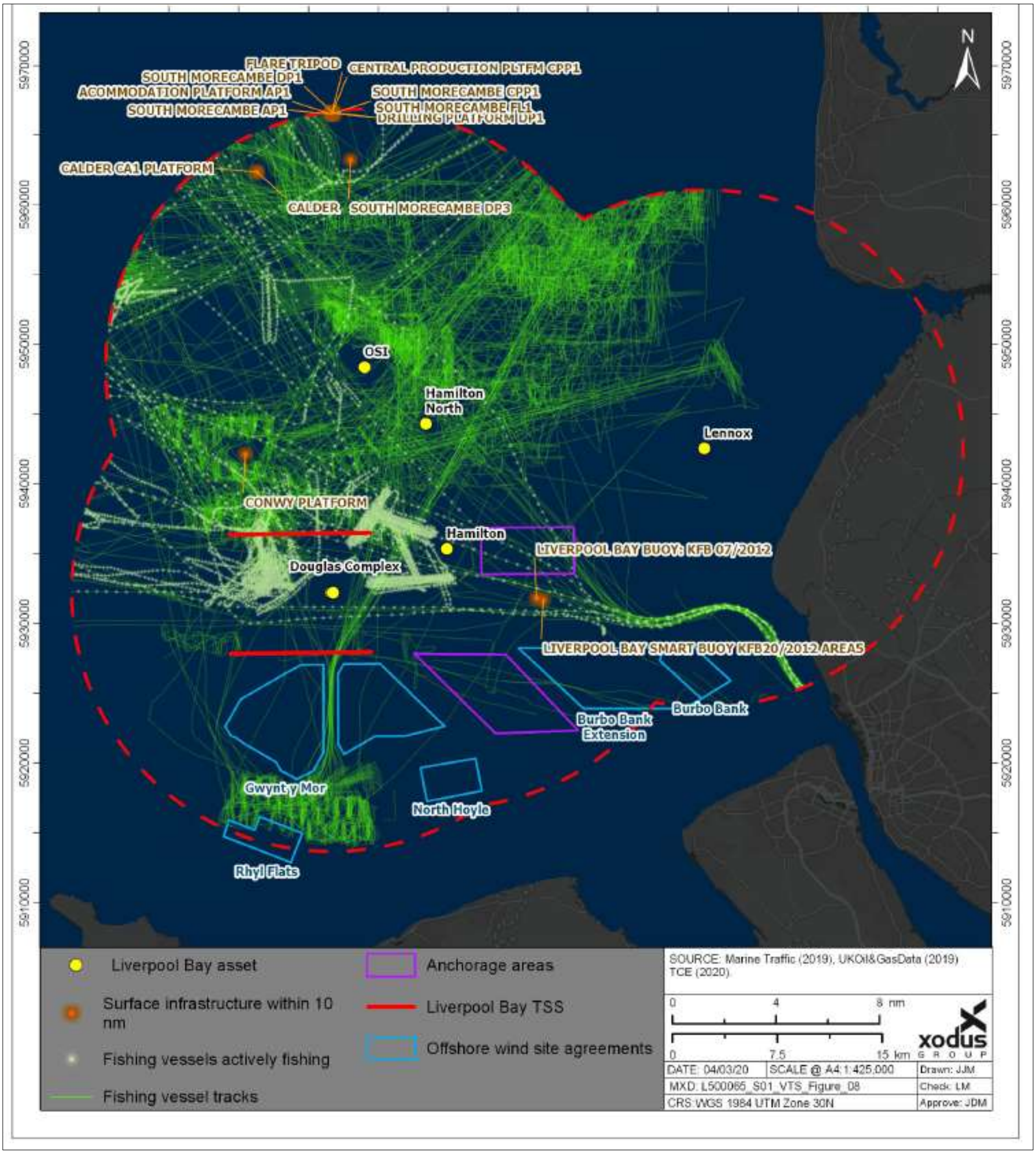


**Figure 13-1 Fishing activity within LBA 10 nm Study Area**

## 14.0 ATTACHMENTS

In the following section free span assessment is reported.

- New 16in Future Pipeline – Douglas CCS to Lennox
- New 12in Future Pipeline – Douglas CCS to Hamilton North

### 14.1 New 16in Future Pipeline – Douglas CCS to Lennox

FreeSpanReport_New 16in_Pipeline_DD

### 14.2 New 12in Future Pipeline – Douglas CCS to Hamilton North

FreeSpanReport_new12in_Pipeline_DD_